INTENSIVE FORESTRY
EFFECTS ON
VANCOUVER ISLAND
DEER AND ELK HABITATS

PROBLEM ANALYSIS

INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH

Province of British Columbia

A cooperative project between the Ministries of Environment and Forests

INTENSIVE FORESTRY EFFECTS ON VANCOUVER ISLAND DEER AND ELK HABITATS

Problem Analysis

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SUMMARY OF CONTENTS

1. This problem analysis was requested by the Technical Working Group directing the Integrated Wildlife - Intensive Forestry Research program on Vancouver Island. Its goal is to evaluate research priorities concerning the ways in which intensive forest management will affect habitat values for deer and elk. Other studies will focus on the ways these animals use their habitats (e.g. habitat selection and population responses), and will be co-ordinated with the forestry/habitat investigations that will follow from this problem analysis.
2. Depletion of old-growth timber inventories has led to intensive management of young forest stands, in which deer and elk habitats are poorly understood.
3. Elk and deer management potentials are greatest on Crown forest land where the goal is integrated resource use. Wildlife managers control little land directly, and have no mandate for habitat manipulation on private land.
4. The objectives of this problem analysis are to review habitat values needed by deer and elk; describe present and future forestry programs; assess impacts of forestry on habitats and rank the impacts by their relative importance; discuss study topics and areas; suggest research priorities; and discuss methodologies for conducting research.
5. Deer capabilities are highest around Quatsino Sound, Nootka Sound, and down the eastern half of Vancouver Island. Elk capabilities are less certain, but are high in areas near Kyuquot Sound as well as other areas on the east coast. Forest capability for Douglas-fir is highest in central Vancouver Island (Coastal Western Hemlock Biogeoclimatic Zone, drier maritime subzone); for western hemlock it is highest on the west and north coasts (Coastal Western Hemlock Zone, wetter subzone).

6. The most important deer and elk habitat values are forage (abundance, quality, and availability), winter range, thermal cover, and hiding cover. Logging or thinning debris may restrict access and reduce use of otherwise valuable habitat.
7. Forest company and B.C. Forest Service management objectives vary greatly. Some organizations aim principally to produce optimum-size sawlogs; others aim to maximize volume yield with less regard for piece size. Silvicultural regimes vary accordingly.
8. On Vancouver Island Crown land, and on private land in Tree Farm Licences, 1983-1988 plans call for 2120 ha of backlog planting, 3832 ha of type conversion (site rehabilitation), 5301 ha of conifer release (mainly "hack and squirt" herbicide applications), 25 536 ha of pre-commercial thinning (juvenile spacing), no commercial thinning, and 20 380 ha of fertilization.
9. Most pre-commercial thinning will occur on the east coast north of Ladysmith, in the Nimpkish River area, and on the west coast south of Nootka Sound. Fertilization will usually accompany pre-commercial thinning. Conifer release programs will be widespread.
10. Forestry effects on habitat values are complex and cannot be generalized - intensive forestry is neither all good nor all bad. Interactions between major forestry activities and important habitat values are discussed.

SUMMARY OF RECOMMENDATIONS

1. Forestry/habitat research should concentrate on areas of high deer and elk capability in the Coastal Western Hemlock Zone, with lower priority given to the wetter subzone of the Coastal Douglas-fir Zone.
2. The most important research topic is winter range in young-growth forests. Which types of natural or managed young stands can act as deer and elk winter ranges, and how effectively can they replace old-growth winter ranges?
3. Another important topic is forage abundance and species composition in managed stands. Which management regimes and sites will produce significant changes in forage as compared to unmanaged stands?
4. Other topics of interest, in descending order of importance, are hiding cover, thermal cover, and debris effects.
5. Research on forestry/habitat should concentrate initially on winter range during winter and forage abundance during summer. Other topics should be addressed later in the program, if at all.
6. Crews investigating forestry/habitat, deer, and elk should work together about 20% of the time. Due to restricted site and forestry treatment variations in intensive deer and elk study areas, the forestry/habitat crew will have to seek study sites across much of Vancouver Island.
7. Research plots have been established by silviculturists from government and industry since the early part of the century to investigate stand tending effects on trees. Where untreated control plots are included, these experiments will allow us to investigate forage and snow responses without conducting extensive experiments of our own.

PREFACE

This problem analysis was prepared for the Integrated Wildlife-Intensive Forestry Research (IWIFR) program being conducted on Vancouver Island by the British Columbia Forest Service and B.C. Ministry of Environment. The IWIFR program began during 1980, is scheduled to run until spring 1986, and has been allocated a budget of $1.6 million for the 6-year period. The program goal is to carry out a co-ordinated research program that will provide information needed for the effective integration of forest and wildlife management on Vancouver Island. To promote participation and information exchanges with public and private interests, the Technical Working Group directing the study includes representatives of forest industry and public conservation groups, as well as staff from the two sponsoring agencies. Further information on the IWIFR program is available in annual reports and in progress reports for component studies, available from Research Branch, B.C. Forest Service or Ministry of Environment, Victoria.

This problem analysis deals specifically with the ways in which intensive forestry treatments modify deer and elk habitat values on Vancouver Island. It will be followed by a working plan and a series of subsequent studies on aspects of the problem. Other major problem analyses focus on Roosevelt elk and Columbian blacktail deer, and concern the ways that these species select, use, and respond to various habitats.

A number of other short-term and support projects are being conducted during the IWIFR program. Details are available in annual reports for the program.

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1 THE PROBLEM

1.1 Introduction

Columbian blacktail deer (Odocoileus hemionus columbianus) and Roosevelt elk (Cervus elaphus roosevelti) are the most important game species on Vancouver Island, accounting for an estimated 167 000 hunter-days of recreation in 1978 (McDaniels Research Limited 1980)[1]. Both species are primarily residents of forest land in coastal British Columbia, where logging and forestry activities cause widespread and drastic changes in habitats. Until recently, habitat protection and management concerns arose mainly from the logging of old-growth timber; but an increasing emphasis by government and the forest industry on forest stand establishment and stand tending activities, commonly termed "intensive forest management", has generated new concerns about the future of Vancouver Island deer and elk populations.

The genesis for the new intensive forest management program, and for increased interest in producing deer and elk habitat through intensive forestry activities, lies in the progressive reduction of the old-growth timber inventory on Vancouver Island over the last 100 years. As the old-growth disappears, annual wood volumes produced from each management area will decline due to the fall-down effect (Pearse 1976, pp.227-228) unless substantial productivity gains in second growth crops can be effected through management. The remnant high-volume old-growth stands are becoming increasingly desirable logging prospects, but at the same time, their value as wildlife habitat is rising because of the dependence of some animal species on late successional or climax stands. For example, deer select old-growth as winter cover in some areas because old-growth intercepts much snow and provides forage in the form of arboreal lichens and rooted vegetation (Jones 1975; Hebert 1979). These requirements are not satisfied

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[1] McDaniels Research Limited. 1980. An evaluation of wildlife enhancement through silvicultural changes in the Sayward Forest. Unpubl. report, B.C. For. Serv. Available from: Strategic Studies Branch, Victoria, B.C.

by most younger stands, and many wildlife managers question whether any young-growth stand (i.e. less than approximately 150 years old) can provide critical deer winter range.

Many questions about other deer and elk habitat values in young-growth stands have yet to be answered. Wildlife and forest managers ask, "Does pre-commercial thinning (juvenile spacing) produce large volumes of nutritious forage? Which young stands provide good hiding cover? If we use herbicides to control brush, does that eliminate elk food? If we attempt to create winter ranges in 60-year-old stands, will deer use them?", and much more. The agencies responsible for managing B.C.'s wildlife (Ministry of Environment) and forests (B.C. Forest Service) must have answers to these questions if they are to achieve their respective goals of maintaining natural numbers and distributions of wildlife (Hebert 1979; D.C. Morrison, pers. comm.) and of planning "the use of the forest ... resources of the crown so that the production of ... timber ... and the realization of ... wildlife ... values are coordinated and integrated..." [Ministry of Forests Act RSBC/Chap.272/Sect.4(c)]. Until 1980, no research on these topics had been carried out in coastal B.C.

The Tsitika Watershed Integrated Resource Plan documented the need for research into "the functional use of second growth forest as critical winter habitat for blacktailed deer" (Tsitika Planning Committee 1978, p.34). Subsequent conflicts between the management programs for forests and wildlife, particularly during extensive "backlog" pre-commercial thinning (see Glossary, p. 66) during 1978/79, proved again the need for applied research. Following a review of research needs in the broad field of wildlife and intensive silvicultural interactions on Vancouver Island (Ellis 1980)[2], the Integrated Wildlife-Intensive Forestry Research program

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[2] Ellis, R.M. 1980. Problem analysis: intensive silviculture-wildlife interactions: research needs on Vancouver Island. Unpubl. report, B.C. For. Serv. Available from: Research Branch, Victoria, B.C.

(IWIFR) was begun. This problem analysis was prepared under the auspices of that program.

1.1.1 IWIFR program

The IWIFR program's prime objective is to determine how the productive capabilities of forested land on Vancouver Island for deer and elk will change in response to intensive forest management practices. Three major projects have been initiated to address this objective. These three projects have, for convenience, been designated the elk, deer, and habitat projects, although they are not mutually exclusive.

1.1.2 Elk, deer, and habitat

Deer and elk are sympatric on Vancouver Island, and compete for forage to some degree. Competition for habitat is not thought to be a limiting factor to the density or distribution of either species except in isolated instances. Hunting, predation (Hebert et al. 1980)[3], winter weather (Jones 1975), and food (Rochelle 1980) are regarded as important limiting factors on each species. Forestry activities may influence an animal's ability to deal with any or all of these factors, through changes in the type and distribution of cover and food.

For biological and logistical reasons it seemed prudent from the start of IWIFR to create two separate but co-ordinated studies to look at elk and deer, and how they used habitat. The best approach to the topic of forestry effects on habitats was not as clear. Initial plans were to have the deer and elk study teams conduct the forestry/habitat studies as central components of their projects, but after considering budgets, manpower, workloads and study areas, it became obvious that another, independent study team was needed. This habitat team would look at areas and forestry

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[3] Hebert, D.M., J. Youds, R. Davies, H. Langin, D. Janz and G.W. Smith. 1980. Preliminary investigations of the Vancouver Island wolf (C.l. crassodon) prey relationships. Unpubl. report, B.C. Min. Environ., Nanaimo, B.C.

activities that the deer and elk crews could not, as well as taking the lead role in designing and co-ordinating habitat evaluations within the deer and elk study areas.

The animal-oriented studies will focus on what habitats the animals use; and on how changes in amounts, qualities, and distributions of habitats affect deer and elk survival, productivity, distribution, and other parameters. The aims and methods for the IWIFR elk study are explained in a problem analysis (Janz et al. 1980a) and working plans (Janz et al. 1980b). Corresponding documents for the deer and habitat studies are in preparation or in press, and are available from the B.C. Ministry of Environment, Nanaimo, or B.C. Forest Service, Research Branch, Victoria.

The habitat study will examine the responses of habitat to forestry treatments. The purpose of this problem analysis is to identify the important issues to be addressed during the habitat study, and to set priorities for research activities.

1.1.3 Terminology

A glossary of terms is presented in the Appendix. Terminology is largely taken from Ford-Robertson (1971), and differs occasionally from the local forestry vernacular. In these cases, the term commonly used in coastal B.C. will appear parenthetically following the first use of the Ford-Robertson term in the text, e.g. pre-commercial thinning (juvenile spacing). From personal preference, the terms "immature" or "young-growth" are used rather than the common term "second-growth".

1.2 Management Options

As in the rest of B.C., wildlife managers on Vancouver Island have direct management control over very little of the island's land base. The largest portion of Vancouver Island is Crown land over which forest tenures grant logging and forest management rights to forest companies or the B.C. Forest Service, and a smaller but significant part is private land,

particularly along the southeast coast in the Esquimalt & Nanaimo Railway belt. Forestry activities (including logging) cause much more habitat change on both Crown and private land than do the deliberate management actions of wildlife managers. As noted by the former regional wildlife biologist for Vancouver Island: "... the District Forester (now Regional Manager) of the British Columbia Forest Service has more control ... over the black-tailed deer resource than does the Regional Wildlife Biologist" (Hebert 1979, p. 136). For that reason, most deer and elk habitat management measures have consisted of requests from Ministry of Environment wildlife biologists to the B.C. Forest Service for protection of certain stands from logging, or for changes in the pattern and timing of logging near protected stands.

As intensive management of young stands becomes common, wildlife habitat management will continue to depend on the integrated resource use policies of the Forest Service, but no longer will the options for controlling habitat effects be limited only to deciding whether to log, or when. Variations in the sequence, intensity, and methods of silviculture treatment will also offer the manager valuable options.

In some cases the stand management regimes that result in maximum wood volume yields or minimum technical rotation periods will have to be modified if deer and elk are to be favoured. The most promising changes for wildlife enhancement involve variations in: (1) final stand density to favour "piece-size" or "volume" management (see Glossary); (2) thinning weight and frequency (together called thinning intensity); (3) age of stand at final harvest; and (4) size and dispersal of treated stands. The IWIFR research program will address these and other related questions.

Forest and wildlife managers have accepted the fact that:

> Timber management is wildlife management. The degree to which it is <u>good</u> wildlife management depends on how well the wildlife biologist can explain the relationship of wildlife to habitat and how well the forester can manipulate habitat to achieve wildlife goals. (Thomas 1979<u>a</u>, p. 13)

Our task during the next few years is to learn how to make intensive forest management into good deer and elk management.

2 OBJECTIVES

The goal of this problem analysis is to assess the expected interactions between forestry treatments and deer and elk habitats, and to recommend specific topics for study. The objectives to be achieved in reaching this goal are:

1) to review the habitat values needed by deer and elk on Vancouver Island;
2) to summarize the present and planned forestry programs for Vancouver Island;
3) to assess the expected impacts of forestry programs on habitat values, and rank the impacts in terms of significance for wildlife and forest management;
4) to suggest specific studies and assign priorites to each;
5) to discuss general methodologies for conducting the recommended studies.

3 PHYSICAL ENVIRONMENT

Deciding where to conduct research on deer and elk interactions with intensive forestry is almost as important as deciding what to research. Ecosystems, climates, forest and wildlife productivities, human access, and other factors vary across Vancouver Island. Government policies and programs for timber and wildlife management reflect these geographic variations. Some forestry activities which consume millions of dollars a year in certain areas of the island, such as pre-commercial thinning on the east coast, are not even contemplated at present in other areas with different forest potentials. Research efforts must be allocated to topics and to areas where projections indicate significant long-term (i.e. 10-20 year) programs.

The major criteria for determining where research is to be conducted

during the IWIFR program should be the long-term wildlife and timber objectives for each area of the island. Unfortunately these objectives are not clearly stated for either resource and remain matters of debate, particularly the longer-term details. In the absence of clearly stated guidelines, IWIFR decisions on research areas must be based on factors such as resource productivities, ecosystem zonation and human access.

In the following sections summaries of the deer, elk, and timber characteristics of Vancouver Island are provided. Study area priorities are discussed later.

3.1 Deer and Elk Distribution and Habitat Capability

Blacktail deer are distributed throughout Vancouver Island in numbers that vary because of hunting, predation, parasites, diseases, local weather, and habitat capabilities. Although it is difficult to separate the influences of the first five factors from the underlying effect of habitat capability, the Fish and Wildlife Branch of the Ministry of Environment in 1977 delineated five zones for deer management, based in part on habitat capability (Davies 1977)[4]. The 1977 zones were also partly based on management priorities and land tenures, but subsequent revisions have resulted in a new set of zones based entirely on the land's apparent capability to support deer (R. Davies, pers. comm.). Figure 1 illustrates the 1982 version of these zones.

The capability zones in Figure 1 are based in part on assessments of historic and current populations and harvest trends, but the relative capabilities assigned have not been confirmed by direct evidence linking habitat parameters to deer productivity. Weather and other factors may be masking the potential productivity of the "low" zone on the southwest coast; for instance, one local observer attributes the low population in Zone 1 in recent years to an extremely heavy snow pack during the winter of 1968/69

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[4] Davies, R. 1977. Habitat protection guidelines for ungulates. Unpubl. report, B.C. Min. Environ., Nanaimo, B.C.

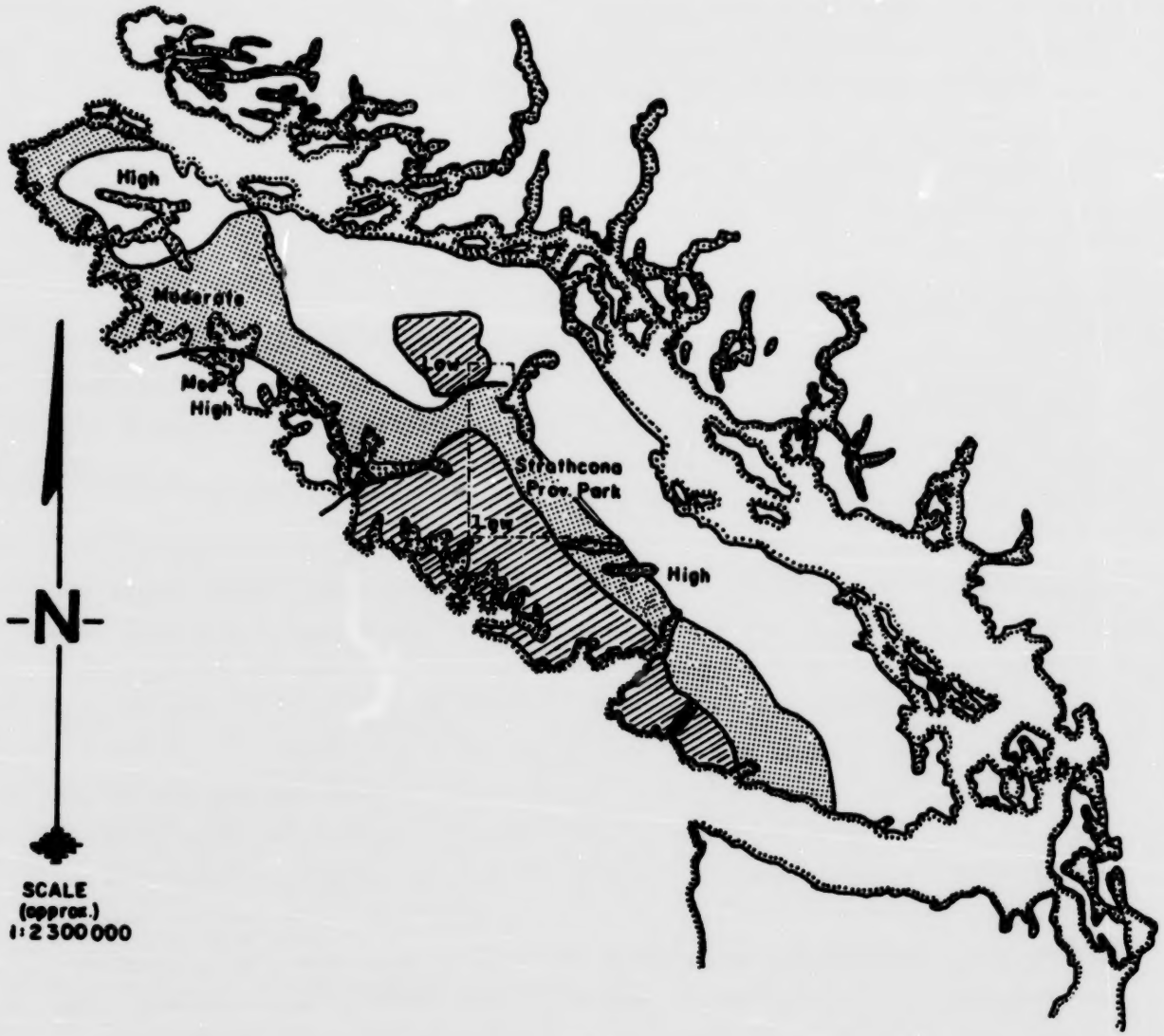

FIGURE 1 Apparent capability of Vancouver Island to support deer.

which apparently led to the death of most deer in the area (B. Mason, pers. comm.).

Roosevelt elk are fewer than deer, but elk are found in scattered local populations throughout Vancouver Island. The high demand for elk hunting and viewing opportunties, as well as an anticipated compatability between elk and intensively managed forests, indicates that management opportunities may be greater for elk than for deer (Hanley 1980, p. 126; D. Hebert, pers. comm.). Capability assessments have not yet been provided for elk.

Management programs for both species are severely constrained on private land by the objectives of the land owners. Most private land on the island lies along the southeast coast, from Campbell River south to Victoria. Regardless of deer and elk production capabilities in this area, wildlife managers can depend only on the goodwill of the land holders to institute wildlife management programs. Many more options are available on Crown forest land, where the managing agencies recognize wildlife concerns and are committed by legislation or policy to integrated resource management.

3.2 Forest Distribution and Capability

Vancouver Island holds some of Canada's most valuable forests and most productive forest land. Douglas-fir (Pseudotsuga menziesii) has historically been the preferred crop and continues to be managed more intensively than other species. Although the standing inventory of mature and older Douglas-fir has been reduced through logging to the point where that species accounted for only 17% of the total volume harvested in Vancouver Forest Region during 1980, more Douglas-fir is planted than any other species on the coast, and most thinning and fertilization is carried out in Douglas-fir stands. However, thinning in western hemlock (Tsuga heterophylla) stands is also extensive, and fertilization after thinning in hemlock may soon increase substantially. Some thinning is also carried out in amabilis fir (Abies amabilis) stands at higher elevations.

Because of the concentration of forest management programs in Douglas-fir

and hemlock stands, conflicts between intensive forestry and wildlife will occur most frequently there, at least in the short-term. Better knowledge of the productive capacities of forest sites has reduced the dependence by foresters on Douglas-fir for reforesting coastal cutovers, but that species is still favoured for most sites in the wetter (CDFb) and drier (CDPa) subzones of the Coastal Douglas-fir Biogeoclimatic Zone, as well as in the drier maritime (CWHa) subzone of the Coastal Western Hemlock Zone (Klinka 1977). It also is a favoured species on some dry and rich sites in the wetter (CWHb) subzone of the Coastal Western Hemlock Zone. Western hemlock is the preferred species on wet, poor sites in the CWHa subzone and on most sites in the CWHb subzone, either alone or in combination with other species.

The most productive sites for Douglas-fir occur in the drier maritime subzone of the Coastal Western Hemlock Zone, and those for hemlock occur in the wetter subzone of the same zone (Klinka et al. 1979, p.51). We can therefore expect the conflicts between deer, elk, and intensive forestry to be most severe where high priority areas for deer and elk management overlap with the CWHa and CWHb subzones. Significant but lesser conflicts will occur in similar portions of the CDFb subzone.

4 HABITAT VALUES

Although wildlife habitats vary greatly among animal species, locations, and seasons, biologists agree that deer and elk habitats everywhere provide three essential elements: food, cover, and water. The quality, abundance, and pattern of these habitat components in any area determine its carrying capacity for either species. The population of any area may or may not reach carrying capacity, depending on other influences on the animals, such as predation and disease.

The concept of carrying capacity is theoretically sound, but it has proven to be extremely difficult to quantify because of the complex ways in which animals affect and are affected by their habitats. Consequently, most habitat studies have tried to evaluate the effects of changes in one or a

few parameters of one habitat component, such as the quality of food or the density and distribution of cover. There has been no framework for tying these narrowly defined studies together in developing wildlife management plans, so managers have faced serious problems in trying to analyze complex habitats and plan habitat manipulations.

Recently the U.S. Forest Service has embarked on a program to develop habitat management handbooks for use throughout the country in integrating wildlife and timber production. The first of these handbooks, produced in Oregon (Thomas 1979b), discussed optimum habitats for deer and elk in general terms without specifiying carrying capacities. It attempted to assist managers by defining the most important habitat values, and also recommended patterns and proportions of cover types and forage areas to satisfy certain population objectives. In future handbooks for other areas, the intent is to refine the habitat categories and synthetic mechanisms to better represent the complexity of the real world, while recognizing that managers need simple ways of assessing habitat changes, such as tabular and graphical approaches (J. W. Thomas, pers. comm.).

The IWIFR program will need to include, towards the end of its term, a means for organizing the knowledge acquired during the research phase into a decision-making framework for forest and wildlife managers. While the U.S. Forest Service handbook approach is one of the available options, computer-assisted habitat analysis is another option being explored (Scoullar 1981)[5]. To guide initial research efforts, however, we must first define the habitat values needed by deer and elk, determine how forest management will change the amounts and qualities of the important habitat types, and predict how these changes will affect deer and elk populations. To do this we must start by addressing habitat parameters individually. Once we understand the many habitat values individually, at least in general

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[5] Scoullar, K. 1981. Problem analysis - developing a wildlife habitat management system. Unpubl. report, B.C. For. Serv. Available from: Research Branch, Victoria, B.C.

terms, we can begin to address them collectively.

The following sections outline the potential list of habitat values that might be of concern. The references quoted are not exhaustive, but were selected to illustrate the current understanding of deer and elk ecology. In many cases, studies of white-tailed deer (Odocoileus virginianus) or mule deer (O. hemionus hemionus) are used to illustrate blacktail deer ecology, and Rocky Mountain elk (Cervus elaphus nelsoni) to represent Roosevelt elk. The assumption of equivalence in habitat ecology between these taxa may not always be justified; IWIFR studies will allow us to test some of the assumptions.

4.1 Food

Both deer and elk are generalist herbivores, that is, their diets are typically composed of a large number of plant species and parts. Except when weather conditions impose severe constraints on food availability, daily diets usually include material from five or more species of plants, and 30 or more species may be eaten in the course of a year. Diets vary greatly among areas, depending on the composition of local plant communities; among seasons, depending on phenological stages of plant growth and physiological states of the animals; and among individuals, depending on sex and age classes and individual preferences.

In most areas, the total biomass of all plant species that contribute to annual elk and deer diets is vastly more than any known population of the animals could consume. However, only a small fraction of the total plant biomass is ever available as forage, due to limitations imposed by characteristics of the plants such as physical distribution, size, and chemical composition; and by characteristics of the animals such as mouth and rumen size, height, body weight, and digestive capability. Because of the complexity of the relationships between these characteristics of animal and plant, there is no simple way to evaluate how much forage is available to any population, or to estimate the proportion of the available forage that is eaten.

Many studies have attempted to define the quality and quantity of forage required by deer and elk, or the amount and quality of forage available in various habitats. In most estimates of available forage, the proportion of the forage biomass that is of adequate quality (i.e. in terms of protein, energy or mineral content, or digestibility) is not measured. Instead, some physical trait of the plants is taken as an assumed correlate of acceptable quality. Common examples of such physical features are the current season's twig and leaf growth, or all growth distal to the point of average maximum diameter at point of browsing. Without testing the relationship between the chosen physical feature and quality, the assumption of a good correlation is open to question, particularly during the typical post-growing season period of declining forage quality.

For the reasons just discussed, forage estimates that attempt to define carrying capacities or use levels must be interpreted cautiously. On the other hand, when forage resources are compared between habitats showing large differences in forage quantities, the confounding effect of quality on quantity is less important. In the following section, local research comparing deer and elk forage resources available in various stands and habitat types is reviewed. The objective here is to point out the magnitudes of differences rather than to define exactly which habitat is the best producer of forage.

4.1.1 Abundance

In coastal B.C. standing vegetation crops are huge. Many forests are similar to those studied by Long and Turner (1975) in coastal Washington, where total above-ground biomass in immature Douglas-fir stands ranged from 64×10^3 kg/ha (dry weight) at 22 years of age to 210×10^3 kg/ha at 73 years. However, as mentioned above, total vegetation biomass is an inappropriate variable with which to characterize forage abundance, because most of the biomass is unavailable to ungulates due to physical, chemical, or physiological restrictions.

Several studies have attempted to quantify available forage production in coastal B.C. and Washington plant communities of differing seral stage and site characteristics, as summarized in Table 1. Summer forage production estimates ranged from 43 to 5813 kg/ha in these studies, although Hanley's estimates (1980) included all understory species present and thus incorporated some unknown amount of non-forage. Based on the data of Gates (1968) and Harestad (1979), summer forage ranges from 113 to 1444 kg/ha in regenerating clearcuts, and from 43 to 846 kg/ha in mature and old-growth forests. Although Hanley's data are not directly comparable due to the included non-forage component, they do confirm the trends indicated by Gates and Harestad in that some clearcuts produce more food than does any older seral stage, but other clearcuts produce less food than some old-growth stands. Hanley's results indicate that closed canopy immature stands produce less food than either younger or older stands.

Winter food production in four studies (Brown 1961; Gates 1968; Harestad 1979; Rochelle 1980) ranged from 7 to approximately 500 kg/ha. In clearcuts the range was 7-400 kg/ha; and in mature and old-growth timber stands, it was 40-500 kg/ha.

Rochelle (1980) found that litterfall was a substantial component of the overall winter forage available on his study area. Arboreal lichens comprised 70-90% of forage litterfall with conifer foliage making up the rest. On three of five sites, litterfall over a 180-day winter period exceeded the amount of rooted forage available in the absence of snow. Burial of rooted forage by snow would increase the proportional contribution of litterfall to total available food. Only Harestad (1979), who included lichen litterfall estimates in his winter forage totals, and Rochelle have measured the litterfall contribution to local deer or elk winter diets.

No clear trends in forage production with site moisture are evident in these data, but this is likely due to confounding effects of stand age and sampling design. When Harestad (1979) studied old-growth stands in a single biogeoclimatic zone, he found forests on mesic and slightly wetter sites to produce far less summer forage than those on drier and wetter sites in the same zone.

TABLE 1 Estimates of ungulate forage production in coastal British *Columbia and Washington*

Location and author	Seral stage	Site	Annual production of summer forage (kg/ha)	Annual production of winter forage (kg/ha)
Western Washington	Clearcut,grass-forb stage			7[a,d]
Brown 1961	Clearcut, shrub-seedling stage			21
	Pole-sapling stand, incomplete canopy closure			196
	Closed canopy immature or mature forest			34
Western Washington	Early seral (Clearcut)	Xeric	4355[c,e]	
Hanley 1980	"	Mesic	4044	
	Early seral (Alder dominant)	Mesic	4124	
	0-1 years after logging (unburned)	Xeric	615	
	2-7 years	Xeric	2711	
	8-13 years	Xeric	4282	
	14-19 years	Xeric	5813	
	Closed canopy immature stand	Xeric	369	

TABLE 1 continued

Location and author	Seral stage	Site	Annual production of summer forage (kg/ha)	Annual production of winter forage (kg/ha)
	Near-climax virgin forest	Xeric	1067	
	Near-climax virgin forest	Mesic	2822	
Parksville, Vancouver Island	4 years after slash-burning		1061[b,f]	62[b,f]
Gates 1968	9 years after slash-burning			255
	10 years after slash-burning		1444	
	12 years after slash-burning		1088	
	14 years after slash-burning		1247	
	Mature timber		481	479
Nimpkish Valley, Vancouver Island Harestad 1979	Old-growth forest	Subhydric	846[c,g,i]	
	"	Hygric	94	90±10[c,g,i,j]
	"	Sub-hygric	107	100±10
	"	Mesic	43	40±10
	"	Submesic	224	220±10
	"	Subxeric	504	500±10
	"	Xeric	295	300±10

TABLE 1 continued

Location and author	Seral stage	Site	Annual production of summer forage (kg/ha)	Annual production of winter forage (kg/ha)
	Old-growth Forest	Mesic, high elevation	700	
	Old-growth forest	Xeric, high elevation	516	
	Clearcut, newly logged		113	40±10
	Clearcut, herb stage		215	15±10
	Clearcut, Fern stage		220	30±10
	Clearcut, shrub stage		286	50±10
	Clearcut, conifer stage		568	400±10
Nimpkish Valley	Old-growth	Low elevation		52-132
Rochelle 1980		Mid-elevation		261-379[c,f,h]

a Air-dry weight.
b Wet weight.
c Oven-dry weight.
d Includes only the four most important shrubs for deer winter forage.
e Includes all species on site, available portion only.
f Preferred deer foods only.
g Includes lichen litterfall.
h Includes lichen and coniferous foliage litterfall.
i Includes all species except bracken fern (Pteridium aquilinum).
j Accounts for food burial by snow.

No published estimates of elk forage production are available for coastal B.C., but Hanley's (1980) mesic sites were important elk habitat in Washington. Mesic and wetter sites studied by Harestad (1979) should approximate total forage production on some Vancouver Island elk habitat, as elk exhibit a strong preference for low-elevation, moist habitats during much of the year (Janz 1980).

4.1.2 Quality

The animal body requires over forty different nutrients (Maynard et al. 1979), but deer and elk forages are typically evaluated for only two parameters, energy and protein (e.g. Wallmo et al. 1977; Seal et al. 1978; Bahnak et al. 1979; Harestad 1979; McCullough 1979; Hanley 1980; Rochelle 1980). Mineral nutrition is sometimes considered; especially intakes of phosphorus, which Halls (1970) considered to be deficient in forages from many areas of North America, and calcium (Radwan and Crouch 1974); but other minerals and the required vitamins have not been shown to be deficient in natural forages except in rare cases (Halls 1970). Probably mineral and vitamin deficiencies, which are common in domestic livestock fed a restricted variety of foods (Maynard et al. 1979), are prevented by the catholic nature of deer and elk diets. It is possible, though, that mineral and vitamin deficiencies are more widespread than is commonly credited, but that difficulties in observing wild animals, in determining a posteriori the cause of death, and in using simplified diets to solve wildlife nutrition problems (Maynard et al. 1979) have obscured these deficiencies.

Until the 1970s the amount of protein in natural deer and elk diets was often regarded as the limiting factor to animal condition and productivity (Einarsen 1946, Klein 1965). Dietz (1965) stated that a dietary level of 6-7% crude protein was the minimum level for winter maintenance of deer, and evaluation of natural forages against this standard seems to confirm that protein deficiency is common in deer foods in coastal B.C. (Gates 1968; Rochelle 1980). However, there has been an increasing realization of the important role played by urea recycling in deer and elk as a mechanism for

nitrogen conservation when diets are low in protein (Campbell 1963; Robbins et al. 1974; Mould and Robbins 1981). This has led to a decreased concern for protein as a limiting nutrient, and an increased emphasis on energy content of feeds and on digestibility.

For elk, protein needs are commonly met during all seasons except winter if minimum energy requirements are satisfied and if forages contain at least 10% crude protein (Mould and Robbins 1981). However, in winter a dietary crude protein level of 5% appears to be near the critical lower limit for nitrogen maintenance due to high fibre contents and slow passage rates of winter feeds. Even levels of crude protein between 5 and 8% can be critical if insufficient forage is available to meet maintenance nitrogen requirements. Mould and Robbins calculated required daily dry matter intakes for a 300-kg Rocky Mountain elk to be 2 kg at 8% crude protein (c.p.), 4 kg at 6% c.p., and 8 kg at 5% c.p.; but concluded that intakes of the order of 8 kg are not usually possible when protein contents are low, due to high lignin and phenolic contents, slow rates of passage, and consequent reduced voluntary dry matter intakes. Thus forage protein content is still implicated as a limiting factor in elk nutrition under some conditions, even though energy may be the more common critical factor as explained below.

Gates (1968) and Rochelle (1980) found crude protein contents in Vancouver Island deer forages to vary with forage class (e.g. shrubs, forbs, grasses), species, season of year, and stand age, but most samples fell in the ranges of 5-19% in spring, 4-15% in summer, and 5-13% in fall-winter. The major exceptions were lichens, which never exceeded a seasonal average of 2.1% crude protein in Rochelle's study; and bracken, which had 33% crude protein in Gate's study area in June. During all seasons the poorer forages were in the 4-8% range where protein content may become limiting.

Moen (1978, p.718) states, "There is a trend toward the use of energy as a fundamental unit of measurement in the assessment of productivity for decision making in wildlife management." He, his co-workers, and others have published extensively on the energy demands for various activities in

Rocky Mountain elk and white-tailed deer, and on forage contributions to energy requirements (see Moen [1981b] for an extensive list of references). Dry matter digestibility of forages *in vitro* is usually used as an index to metabolizable energy because: (1) gross energy in forages is nearly a constant 4500 kcal/kg; (2) there is nearly a 1:1 relationship between forage dry matter digestibility *in vivo* and digestible energy; (3) dry matter digestibility *in vitro* is well correlated with digestibility *in vivo*; and (4) metabolizable energy is normally in the range of 72-94% of digestible energy (Wallmo *et al.* 1977; Rochelle 1980; Moen 1981a). Known energy requirments for activities in elk (e.g. Robbins *et al.* 1979) and deer (Moen 1978), plus digestibility coefficients, can be used to predict forage intakes required to satisfy various levels of activity (Moen 1978, 1981a).

Three local studies have placed a major emphasis on dry matter digestibility as an index of forage quality: Harestad (1979) ascribed many of the observed shifts in seasonal home ranges in Nimpkish Valley radio-collared deer to changes in the density of available digestible dry matter; Rochelle (1980) conducted extensive digestibility analyses for forages from different habitats, forage classes and seasons of the year; and Hanley (1980) concluded that dry matter digestibility was the best measure of forage value to Rocky Mountain elk, but differed with Harestad (1979) by concluding that cell soluble content was the best forage quality measure for black-tailed deer because standard digestibility trials overestimate the rumen turnover time in deer. Forage energy values (however expressed) were considered by all these authors to be important parameters of habitat quality.

As with protein, dry matter digestibility varies among forage classes, seasons, species, and stands (Rochelle 1980). In the Nimpkish Valley, forage class digestiblity averages ranged from 21-67% in spring, 28-76% in summer and 33-78% in fall-winter.

4.2 Cover

Elk and deer use specific plant communities and terrain as "cover" for many different purposes. Various names have been given to the most

important cover types. For example, shelter from temperature extremes and wind is called thermal cover (Beall 1974); shelter for resting and avoiding predators and hunters is called hiding, escape, or security cover (Thomas et al. 1979); and shelter with low snow depths and/or good winter forage is called winter range (Jones 1975). Other activities have been shown in some studies to be correlated with particular habitat conditions, although the relative importance of these correlations is not well established. For example, Collins et al. (1978) found Rocky Mountain elk preferred specific forest types or terrain for avoiding insects, resting, travelling, ruminating, and grooming, but considered forage availability and associated grazing values to be most influential in habitat selection. Other potentially important cover types are rutting and natal (i.e. fawning and calving) cover, but the hypothesized value of these cover types relates to security, thermoregulation, and food acquisition.

In the sections below, the major cover types are described and comments are provided on their importance to deer and elk on Vancouver Island.

4.2.1 Winter range

Winter range is considered by most people to be the key habitat component for both deer and elk, not only on Vancouver Island but across the northern part of the continent. On Vancouver Island the value of winter range lies in the amelioration of snow conditions as well as in forage production, and winter range is not so much a cover type as a seasonal habitat complex. However, the influence of snow on movement and forage availability is so important, and winter ranges are so specialized in their characteristic features, that winter range must be discussed as a unique habitat type.

Winter ranges appear to be important because they allow animals to achieve a higher level of net energy intake than is possible in other habitats (Harestad 1979). Often this means the animals are minimizing

losses rather than achieving a positive energy balance. Usually winter ranges that are used when snow is deep provide a combination of reasonably abundant forage and an overstory of trees that serves to enhance the mobility of animals by intercepting or redistributing snow. Other habitats may have either more food or better snow conditions, but not the required combination of the two. Because both forage availability and snow must be evaluated together, several different combinations of stand, site, and topographic conditions may serve as winter range under any given set of winter weather conditions. As snowpacks become deeper, the acceptable habitats for winter ranges become progressively restricted.

In many winters, elk and deer lose weight no matter what the quality of their habitats, so their body condition on entering the winter is also important. Elk and deer with large fat reserves at the beginning of winter may survive longer on poor winter range than will thinner animals on better range (Mautz 1978). In the most severe winters, pre-winter condition may be the key to survival of any deer if forage is so scarce and snow so deep that animals merely "wait the winter out", minimizing movement and consequently energy expenditure at the cost of energy intake.

In mountainous regions of coastal B.C., long periods of deep snow occur in some years. Deep snow covers food supplies and restricts animal mobility, leading in some cases to severe population declines due to malnutrition (Smith, [1969]). Evidence indicates that during prolonged periods of deep snow both deer and elk seek special forest conditions as winter range, or at least those deer and elk inhabiting certain stands survive while others die (Jones 1975; Bunnell 1979; Harestad 1979; Hebert 1979; Janz 1980). The ideal winter range for deer in the mountainous central spine of Vancouver Island is generally thought to be an old-growth stand predominantly composed of Douglas-fir, usually intermixed with western hemlock and western redcedar (Thuja plicata). Canopy closure is 65% or higher; and arboreal lichens, especially Alectoria sarmentosa, are abundant in the upper canopy. The understory is abundant in shrubs such as red huckleberry (Vaccinium parvifolium) and salal (Gaultheria shallon), and

small rock outcrops occurring among the trees are beneficial. The slope is 15-60%, aspect is 135°-270°, and elevation is 300-650 metres.

Not all known winter ranges meet these criteria. Some occur on shallower slopes and northerly aspects; some have little understory or reduced amounts of arboreal lichens. In areas where little snow occurs there is probably no such thing as critical winter range. Although no minimum standards for adequate winter range have been established for any set of weather conditions, empirical evidence does tell us that most old-growth stands on steep south slopes harbour more deer in severe winters than do either clearcuts and very young stands (less than 20 years old) on any slope, or old-growth stands on slopes and aspects outside the preferred limits. There is less but still substantial evidence that 20- to 60-year-old natural stands are not usually good winter ranges. Managed stands from 20 to 60 years old and natural stands between 60 and 150 years old are uncommon on Vancouver Island, so their value as winter range is essentially unknown.

The characteristics of the best winter ranges for elk on Vancouver Island are not as well-defined as for deer due to fewer field studies of elk. During mild winters, clearcut areas and immature forests can provide good elk habitat, but deep snow results in greater use of old-growth forests. Critical winter range for elk is thought to be low-elevation old-growth forest, but on flat valley bottoms or gentle lower slopes rather than on steep slopes like deer winter ranges (Janz 1980).

The nature of "critical" or "mild" winter range (Harestad 1979) is dependent on climatic patterns and management objectives. Where snow never exceeds a few inches in depth or lasts more than a week, winter range is not needed for snow moderation. If heavy snows occur only every 20 years, and management objectives allow for occasional population declines, winter range is again not critical. However, where heavy snows are common, deer or elk are abundant, and hunting pressure is high, extensive areas of critical and mild winter range are needed if population objectives are to be reached.

Climatic characteristics and Ministry of Environment management objectives have prompted a great concern by deer and elk managers for winter range in all mountainous portions of Vancouver Island (Hebert 1979). Extensive stands of old-growth timber have been reserved from logging for periods of from 5 to 150 years, resulting in many conflicts among timber companies, the Forest Service, the Ministry of Environment, and the public. The economic significance of deer and elk winter range reserves was calculated for two Tree Farm Licences (TFLs) on north-central Vancouver Island in a recent report (B.C. Ministry of Environment and Ministry of Forests 1983). These two TFLs probably contain a higher proportion of winter range than any other area of Vancouver Island, but their total area is less than 10% of Vancouver Island's area.

In the two TFLs, 10 396 ha of timber are reserved primarily for deer and elk winter ranges, although many winter ranges also serve other functions such as providing firebreaks between logged areas. The approximate total timber volume in the existing winter range reserves is 5.8×10^6 m^3. If this volume of timber is permanently removed from the inventory of old-growth contributing to the allowable annual cuts (AACs) for the two TFLs, the combined AACs will be reduced by 103 790 m^3. In stumpage alone this will result in an average loss of slightly over $1 million in Crown revenues annually. The report estimates the present net value of the economic returns that would result from logging the old-growth winter ranges at $14.1 million. This figure has been criticized as being too low, because of its failure to include personal income tax revenues and the value of indirect employment generated by the forest industry. However, it serves to illustrate the very high costs associated with preserving old-growth stands for winter ranges on only a small part of Vancouver Island. Across the whole island the total costs would be several times higher.

There is a strong economic incentive, then, to find alternative means of sustaining deer and elk populations through hard winters. Because the old-growth winter ranges serve many other purposes such as soil protection, firebreaks, ecosystem reserves, and habitat for other wildlife that prefers

or depends on old-growth habitat, it is not likely that all the stands reserved now will ever be logged, but even harvesting of half the stands would result in very significant dollar returns.

4.2.2 Hiding cover

Hiding cover, also known as escape and security cover, has recently been mentioned frequently as an important habitat component for deer and elk (Bunnell and Eastman 1976; Thomas et al. 1979; Janz 1980; Tomm et al. 1981). It is usually defined as suitable vegetation or topography to screen animals from the view of predators or hunters. Other functions or types of security cover may be important as well, such as vantage points from which bedded animals can survey surrounding areas, or special topographic or vegetation types in which fleeing animals can escape pursuing predators.

Distance to cover is well known to affect the degree to which deer and elk use open areas, especially clearcuts. Willms (1971) showed that deer use in the Nimpkish River Valley decreased towards the centres of large clearcuts, Lyon (1975, 1980) demonstrated the same phenomenon for elk in Montana, and Tomm et al. (1981) found similar responses by deer and moose in Alberta.

In most reports mentioning the value of hiding cover, no attempt is made to evaluate the relative quality of cover provided by different habitats. Only Thomas et al. (1979) have established minimum screening standards, which determine whether a given timber stand is suitable as hiding cover. They define hiding cover as any vegetation capable of hiding 90% of a standing deer or elk from human view at a distance of 61 m or less. This standard was initially selected arbitrarily, but subsequent evaluation of elk hiding behaviour in eastern Oregon has supported its validity (J. E. Dealy, pers. comm.). No descriptions of vegetation which meets this standard have yet been published, and its applicability to Vancouver Island habitat conditions and to local deer and elk behaviour is undetermined.

4.2.3 Thermal cover

Perhaps more for thermal cover than for any other habitat value, one is

confronted by the question "How can preference be distinguished from need?". Wild elk and deer obviously use certain habitat types in preference to others when temperatures rise or fall beyond the thresholds of some optimum range (Ozoga 1968; Miller 1970; Beall 1974; Leckenby 1977; Thomas et al. 1979; Euler and Thurston 1980). Forest cover and ground cover are known to mediate the rate of heat exchange between an animal and its environment through the four modes of heat transfer: radiation, convection, conduction, and evaporation (Moen 1973). The weather conditions under which deer and elk require special cover types to mediate heat exchange have not been well defined, however. Attempts to measure the physiological responses of captive animals to changing environmental conditions have led to contradictory results in many cases. For example, experiments with captive white-tailed deer held in indirect calorimetry chambers indicated that a winter comfort zone existed between 20°C and 5°C, and that heat production increased 75% when the temperature fell through this range (Silver et al. 1971; Holter et al. 1975). Convective and long-wave radiative heat losses would be minimal in that artificial environment, so under field conditions the upper and lower limits of the comfort zone should be above 20°C and 5°C respectively during windy conditions or under less than completely closed canopies. However, behavioural observations of blacktail deer indicate that cold stress does not modify behaviour until temperatures fall substantially lower than 5°C (Miller 1970). Conversely, heat production falls during spring, summer, and fall in white-tails held indoors as temperature rises from -20°C to 37°C (Holter et al. 1975), indicating no significant stress occurs; yet experiments with mule deer held outdoors in bright sun indicate that severe stress (as evidenced by rapid respiration rates and extreme agitation) occurs above 30°C (C. Robbins, pers. comm.). Under field temperatures as low as -20°C, Robbins has not been able to replicate heat production increases that occurred with the same animals at higher temperatures when held indoors in indirect calorimetry chambers.

The reasons for these contrasting results may lie in different feeding levels, experimental conditions, animal species, degrees of metabolic

adaptation, levels of excitement, or other factors. In any case, there is no clear evidence that deer and elk physiologically "need" thermal cover, especially under thermal regimes as mild as those on Vancouver Island. The emphasis given to thermal cover by Thomas et al. (1979) is best supported by behavioural observations such as those of Beall (1974), but the adaptive value of thermal cover preferences has not been documented.

4.2.4 Other cover types

There is little concern among wildlife managers for the effects of forestry operations in coastal B.C. on cover types other than those discussed above. The only other serious question for elk or deer relates to calving cover for elk. Calves are preferentially dropped in low-elevation, flat areas near water where deciduous understories are abundant (D. Janz, pers. comm.). High-quality forage and hiding cover are available there, but could be greatly reduced by logging, fire, or herbicides.

4.3 Debris

Heavy accumulations of downed woody debris result from logging and thinning in some stands. Several people have observed very low levels of deer use in backlog pre-commercially thinned stands with heavy debris in the Sayward Provincial Forest since 1979; and studies by Lyon (1975) in Montana indicate that slash depths of 0.5 m and more will substantially reduce elk use of clearcuts. Lyon has not quantified the density or coverage of slash in his study area. In Arizona, Reynolds (1966) found deer use was lower in selectively logged pine stands from which some slash was removed than where slash was undisturbed, but maximum slash ground cover was only 6.8%. No published reports have evaluated the rate at which blacktail deer use decreases with increasing debris height and density, but accumulations covering more than 75% of the ground surface and exceeding 2 m in height, as have resulted in some cases from backlog pre-commercial thinning in the Sayward Provincial Forest, are certain to have a substantial negative effect.

5 FORESTRY PROGRAMS

The following discussion of forest product objectives, treatment regimes, and planned activities has been compiled from a number of unpublished Forest Service and company documents, and from conversations with silviculturists. Copies of all documents are available on request.

The discussion of objectives is limited to those of B.C. Forest Products Limited (BCFP), MacMillan Bloedel Limited (MB) and the B.C. Forest Service (FS) because BCFP and MB represent opposite extremes amongst the large forest companies; and because of the size of the FS intensive management program.

5.1 Product Objectives

The amount of intensive forest management conducted on Vancouver Island, and the management regimes employed (i.e. the sequence, timing, and form of forestry treatments) are dependent on the product objectives of managers. The objectives of the three organizations most active in intensive management are:

BCFP - To maximize merchantable mean annual increments by achieving culmination of mean annual increment at a mean stand diameter of 45 cm dbh.

FS - To manage even-aged stands for the production of sawlogs. The usual objective is to produce a stand with mean dbh of 45 cm.

MB - To maximize merchantable volume produced from even-aged stands, within the constraints of product demand forecasts (e.g. pulpwood vs. sawlogs).

Because these objectives are not official policy statements but come from silviculturists in unpublished reports, they may not fully express organizational goals, but they do provide an interesting contrast. Of the three, BCFP is most explicit, prescribing both a piece-size criterion (dbh) and a rotation length criterion. The FS gives a general piece-size standard, but does not specify how rotation length will be determined. MB sets volume maximization as its objective, but allows for flexibility in response to changing demands.

5.2 Treatment Regimes

Managed-stand yield projections are currently so imprecise that today's standards for stocking, thinning, and fertilization should be taken as best guesses. There will be frequent changes to the preferred management regimes as better managed stand yield tables are developed and as forecasts of local and international product demand and supply improve. Forestry prescriptions will also become more site-specific as the silvicultural data base improves, to take account of the different reactions among species to microclimate and soil variations.

Current pre-commercial thinning standards for the large coastal Tree Farm Licensees, the FS, and several companies and government agencies in the U.S. are shown in Table 2. Planting and commercial thinning standards are also shown for the FS, BCFP, and MB. All standards are guidelines, and actual densities achieved in practice will vary in many cases. For example, BCFP explicitly allows a 10-15% margin above and below their pre-commercial thinning standard.

Two conclusions can be drawn from Table 2. First, there is no single ideal management regime. Forestry regimes will vary greatly across Vancouver Island due to variation in land tenure and growing sites. Second, because there is such variety in forestry regimes, suggesting uncertainty in the industry, wildlife habitat research should not be limited to investigation of the effects of current silvicultural practices, but should allow for more latitude in stocking densities and other factors in future.

Silvicultural regimes include more than planting and thinning. Site preparation activities such as burning or scarifying are followed by either planting or natural seeding. Fertilization may take place one or more times following planting or thinning. Weeding and cleaning may be conducted in young stands to suppress competing vegetation. Crop-tree pruning may improve sawlog quality.

Except for slashburning and fertilization these other practices are uncommon at present. Standards for slashburning are very difficult to set or achieve and will not be described here. Urea fertilizer is the nitrogen

TABLE 2 Stocking standards for planting and thinning[a] (stems/ha)

Agency	Planting		Pre-commercial thinning					
			With commercial thinning		Without commercial thinning		Commercial thinning	
	Douglas-fir	Hemlock	Douglas-fir	Hemlock	Douglas-fir	Hemlock	Douglas-fir	Hemlock
B.C. Forest Service	850	1200	750	850	500	600	350	400
B.C. Forest Products	750-800	750-800	Comm. thinning not planned		600±60[b] 500±60[c] 400±60[d]	600±60[b] 500±60[c] 400±60[d]	Comm. thinning not planned	
MacMillan Bloedel	1100	1700	600-1100[e]	850-1600[e]	625	900	400-1100[e]	600-1600[e]
Crown Zellerbach (Canada)	-	-	700-800	800-1000	700-800	800-1000	-	-
Canadian Forest Products	-	-	625-800	625-800	500	500	-	-
Tahsis	-	-	625	816	-	-	-	-
Western Forest Products	-	-	-	700-775	-	625	-	-
Crown Zellerbach (U.S.)	-	-	700	850	500	600	-	-
Weyerhauser (U.S.)	-	-	740-860	1200	550	900	-	-
U.S. Forest Service	-	-	750-950	825-1050	600-750	650-825		
Washington State Dept. Natural Resources	-	-	800-1000		600-800			

[a] Thinning densities are residual (i.e. post-thinning) stocking levels.
[b] Good sites.
[c] Medium sites.
[d] Poor sites.
[e] Depends on stand height at which future thinning will occur.

source in most fertilization programs, where it is applied at a rate of 200 kg N/ha (435 kg urea/ha).

5.3 Planned Forestry Activities

Since the draft of this problem analysis was prepared during early 1982, the economic recession and resulting restraint measures imposed by government and industry have caused widespread reductions in the forestry programs planned for the next five years. In virtually all cases, these reductions are short-term measures only, with full-scale programs due to resume when the economy recovers. The original 1982-1987 projections have been retained as an indication of the expected annual scale of silviculture programs planned for Vancouver Island when peak activity resumes. During the 1983-1988 period, however, the total area on Vancouver Island to be treated will be reduced to the following levels from those shown in Tables 3 and 4: site preparation - 5116 ha; planting - 12 688 ha; brushing and weeding - 1359 ha; backlog planting - 2120 ha; site rehabilitation - 3832 ha; conifer release - 5301 ha; juvenile spacing - 25 536 ha; commercial thinning - none; and fertilization - 20 380 ha.

Tables 3 and 4 present detailed basic and intensive silviculture plans for Vancouver Island Crown land, as five-year projections from 1 April 1982 to 31 March 1987 (Brand 1981)[6]. The tables were compiled by Tree Farm Licence and Timber Supply Area. In some cases these management units occur partly on Vancouver Island and partly on the mainland, so to prepare summaries of Vancouver Island activities only, proportionate reductions were made where necessary, based on the proportion of the total unit area that lies on Vancouver Island. In most cases, this process probably underestimates Vancouver Island activities, because silvicultural activity is usually greater there than on the mainland.

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[6] Brand, D. 1981. 5-year silviculture plan, Vancouver Forest Region: April 1, 1982 - March 31, 1987. Unpubl. report, B.C. For. Serv. Available from: Vancouver Forest Region, Burnaby, B.C.

Unit	Location	Area denuded (ha)	No treatment (ha)	Area treated per year (ha)			
				Site preparation		Planting	Brushing and weeding
				Burning	Mechanical		
Quadra Timber Supply Area (TSA), Crown portion	Sayward Forest, isolated blocks in E & N Railway Belt	679	226	141	21	453	149
Nootka TSA, Crown portion	West coast north to Brooks Peninsula	2673	1121	663	48	1552	256
Kingcome TSA, Crown portion	Cape Scott area, Quatsino Sound south to Brooks Peninsula	486	123	178	19	363	205
Tree Farm Licence (TFL) #2, Crown Zellerbach	Ladysmith, Nanaimo Courtenay, Bonanza River	NA[a]	NA	339	-	583	-
TFL #6, Western Forest Products	Quatsino Sound area	NA	NA	229	15	937	55
TFL #7, MB	Salmon River drainage	NA	NA	177	-	336	-
TFL #19, Tahsis	Nootka Sound area	NA	NA	150	50	900	57
TFL #20, MB	Clayoquot Sound area Nootka Sound	NA	NA	378	45	691	-
TFL #21, MB	Barkley Sound area	NA	NA	474	160	1909	-
TFL #22, BCFP	Port Renfrew to Nootka Sound	NA	NA	758	20	1441	234
TFL #25, Western Forest Products	Sooke, Naka Creek, Port McNeill areas	NA	NA	200	-	240	5
TFL #27, BCFP	Nitinat Lake area	NA	NA	52	-	164	15
TFL #37, Canadian Forest Products	Nimpkish River drainage	NA	NA	600	40	630	20
TFL #39, MB	White, Adam, Eve, Tsitika and Benson River drainages	NA	NA	290	3	532	-
TOTALS		NA	NA	4629	421	10 731	996

[a] Not available

TABLE 4 Five year intensive silviculture program for Vancouver Island, excluding private land outside Tree Farm Licences (from Brand 1981). See Table 3 for unit locations

Unit	Year	Area treated per year (ha)					
		Backlog Planting	Site Rehabilitation	Conifer Release	Juvenile Spacing	Commercial Thinning	Fertilization
Quadra Timber Supply Area (TSA), Crown portion	82/83	56	99	142	529	18	1152
	83/84	134	106	134	494	23	1091
	84/85	150	258	180	495	34	1723
	85/86	128	266	106	410	33	1292
	86/87	110	287	100	352	45	874
Nootka TSA, Crown portion	82/83	635	106	629	570	-	-
	83/84	210	110	650	482	10	480
	84/85	250	130	525	580	10	-
	85/86	200	180	625	533	10	-
	86/87	100	180	604	463	10	-
Kingcome TSA, Crown portion	82/83	15	15	117	128	-	8
	83/84	19	38	130	159	-	15
	84/85	58	154	125	186	-	37
	85/86	25	170	111	185	-	22
	86/87	70	184	121	183	-	22
Tree Farm Licence (TFL) #2, Crown Zellerbach	82/83	-	-	21	617	-	-
	83/84	-	-	21	612	-	-
	84/85	-	-	21	683	-	-
	85/86	-	-	36	775	-	120
	86/87	-	-	36	780	-	120
TFL #6, Western Forest Products	82/83	-	5	353	310	-	-
	83/84	-	5	481	310	-	-
	84/85	-	5	320	350	-	-
	85/86	-	5	320	395	-	-
	86/87	-	5	370	395	-	-
TFL #7, MB	82/83	-	-	150	260	-	-
	83/84	-	-	140	260	-	-
	84/85	-	-	130	260	-	-
	85/86	-	-	130	260	-	-
	86/87	-	-	130	260	-	-
TFL #19, Tahsis	82/83	100	30	200	450	-	880
	83/84	100	30	200	450	-	500
	84/85	100	30	200	450	-	300
	85/86	100	30	200	450	-	-
	86/87	100	30	200	450	-	-
TFL #20, MB	82/83	20	-	239	190		-
	83/84	20	-	239	190	-	-
	84/85	20	-	239	190	-	-
	85/86	20	-	239	190	-	-
	86/87	20	-	239	190	-	-

Unit	Year	Area treated per year (ha)					
		Backlog Planting	Site Rehabilitation	Conifer Release	Juvenile Spacing	Commercial Thinning	Fertilization
TFL #21, MB	82/83	-	20	522	515		-
	83/84	-	20	497	515	-	-
	84/85	-	20	487	515	-	-
	85/86	-	20	392	580	-	-
	86/87	-	20	367	580	70	-
TFL #22, BCFP	82/83	-	95	215	1670		2100
	83/84	-	105	230	1575	-	2150
	84/85	-	105	255	1615	-	1700
	85/86	-	105	255	1650	-	1750
	86/87	-	105	255	1650	-	1800
TFL #25, Western Forest Products	82/83	-	-	72	150		100
	83/84	-	-	54	150	-	100
	84/85	-	-	24	150	-	100
	85/86	-	-	12	180	-	100
	86/87	-	-	12	180	-	100
TFL #27, BCFP	82/83	-	-	15	160		-
	83/84	-	-	15	140	-	-
	84/85	-	-	15	120	-	-
	85/86	-	-	15	120	-	-
	86/87	-	-	15	120	-	-
TFL #37, Canadian Forest Products	82/83	100	-	40	1500	40	1300
	83/84	100	-	40	1500	40	1300
	84/85	50	-	40	1500	40	1300
	85/86	-	40	40	1500	40	1300
	86/87	-	40	40	1500	40	1300
TFL #39, MB	82/83	-	-	315	398	-	-
	83/84	-	-	281	472	-	-
	84/85	-	-	210	548	-	-
	85/86	-	-	202	548	-	-
	86/87	-	-	202	548	-	-
TOTALS	82/83	926	370	3030	7447	58	5540
	83/84	583	414	3112	7309	73	5636
	84/85	628	702	2771	7642	84	5160
	85/86	473	816	2683	7776	83	4584
	86/87	400	851	2691	7651	165	4216
GRAND TOTAL	82/87	3010	3153	14 287	37 825	463	25 136

The summary of basic silviculture plans indicates that prescribed fire will continue to be greatly dominant over mechanical site preparation (scarification), and that weeding and cleaning (brushing) will remain relatively minor activities.

The dominant intensive silviculture activity will be pre-commercial thinning (juvenile spacing). Over 7000 ha will be treated per year, and about 65% of this total will be conducted by BCFP, MB, and Canadian Forest Products (CFP). Most activity on Crown or Tree Farm Licence land will occur on the east coast of the island north of Ladysmith, in the Nimpkish Valley area, and on the west coast south of Nootka Sound.

Fertilization will be the second most extensive activity, usually in combination with pre-commercial thinning. BCFP, CFP, and the FS will have the major programs, but MB may initiate a major fertilization program as their Designed Forest System develops (MacMillan Bloedel Limited 1981). Current plans call for little fertilization on the west coast, except on BCFP's TFL 22 south of Nootka Sound.

Conifer release will also form a large program. Almost all conifer release is carried out in deciduous stands that have overgrown planted or naturally established conifers, and is accomplished by "hack-and-squirt" herbicide applications. The planned 2500 to 3000 ha annually are distributed evenly over Vancouver Island.

Site rehabilitation (type conversion) will take place on a restricted basis (less than 900 ha annually); but because both it and weeding/cleaning operations will be conducted largely on low-elevation moist sites that are often important as elk range, they may have impacts out of proportion to their areal extent.

Commercial thinning plans are probably conservative due to the current poor market conditions, especially for small wood. Only 50 to 175 ha per year are planned, but improved markets could bring a significant increase in this activity. MB has set an objective of producing 5% of their coastal cut from thinnings by the year 2000, and 20% by 2020.

Backlog planting means planting on areas that were denuded by logging or

fire some years ago and have not been satisfactorily restocked. Impacts of this activity on wildlife habitat are no different than is normal planting.

6 PROBLEM DEFINITION

6.1 Forestry Effects on Habitat Values

The habitat value of a forest stand will change many times over the course of a rotation period under intensive forest management. A "piece-size" regime designed to produce sawlogs might consist of the following series of prescriptions, each affecting an area's wildlife habitat value differently: following clearcutting, burn slash or scarify if necessary to reduce debris or to expose mineral soil for planting; plant Douglas-fir at 1100 stems/ha; weed or clean in the first 10 years if weed or brush competition is severe; pre-commercial thin to 750 stems/ha when trees are 12 years old and 7.5 m tall; fertilize with 200 kg N/ha every 5 years after pre-commercial thinning; commercial thin to 300 stems/ha at 30 years of age, 30 cm dbh and 20 m tall; clearcut at 40-50 years, 45 cm dbh and 32 m tall. Some managers would choose to apply these treatments at other intensities or time; or, because of different product objectives, site conditions, or other reasons, might use another regime entirely.

Habitat responses could be drastically different under different regimes, so it is not possible to generalize about the effects of intensive forestry on deer and elk habitat. Even a single type of treatment may have variable effects on a single habitat value, depending on when and where the treatment is applied. Figure 2 illustrates a hypothetical but probably realistic difference in forage production trends over a rotation period as a result of different thinning regimes in a Douglas-fir stand (CWHa subzone, Douglas-fir - salal - Oregon grape association). The top line represents a regime in which initial stocking density is low and thinnings are infrequent and heavy. This causes an open canopy for long periods, and stimulates heavy understory growth. The lower line represents a regime with an initially higher stocking density followed by lighter and more frequent

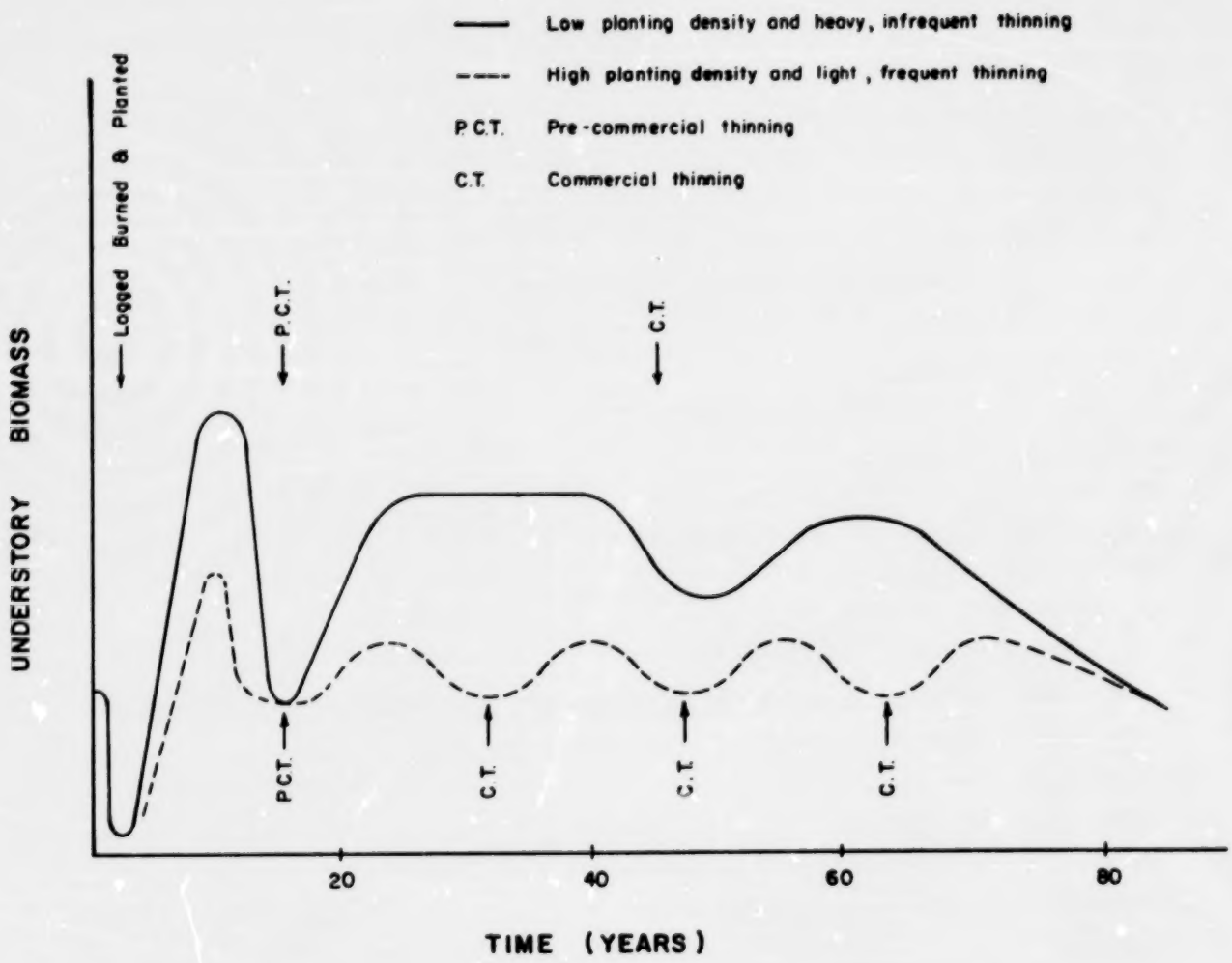

FIGURE 2 Understory biomass as affected by two thinning intensities.

thinnings. The lighter thinnings open the tree canopy only slightly and it closes quickly again each time, leading to much less understory growth.

The complexities of forestry effects on habitat make it imperative that interactions be assessed on a treatment vs. habitat value basis (e.g. fertilization effects on hiding cover), and that research concentrate only on those interactions that are important enough to influence deer, elk and forest management strategies. In order to isolate important interactions from others considered minor or irrelevant during the preparation of this problem analysis, an interaction matrix was prepared, displaying all expected forestry treatments against all potentially important habitat values. Each matrix cell was assigned a positive, negative, or zero value depending on whether the effect of the corresponding treatment was expected to be beneficial, detrimental, or negligible on that particular habitat value. The matrix was then discussed with members of the IWIFR Technical Working Group and others to identify which treatments and habitat values should be subjects for IWIFR habitat research. The specific interactions most suitable for immediate research emphasis were also considered during the discussions. These discussions and a subsequent literature review led to the research conclusions contained in this document.

Table 5 is a simplified version of the initial, more comprehensive interaction matrix. It illustrates only those treatments and habitat values seriously considered as research subjects. The nature of each interaction is described below. Entries in the table indicate the main effect over a term of 10 to 20 years following the treatment. Initial effects may be opposite, e.g. logging reduces understory vegetation through disturbance, but later regrowth increases understory biomass to levels higher than in the original stand.

In the preparation of Table 5, several forestry treatments were excluded. These included scarifying, left out because this practice is presently uncommon and potential study sites are very few; direct seeding, because past experience with the technique has shown it to be unfeasible and wasteful of expensive seed; conifer release and type conversion, because

TABLE 5 Interaction matrix showing effects of forestry activities on important deer and elk habitat values

Habitat values	Forestry treatments				
	Logging[a]	Burning	Planting/Natural seeding	Thinning	Fertilization
Forage abundance	+	-	-	+	+ or -
Forage quality	0	0	0	0	+
Diet composition	+	+ or -	-	+	+ or -
Forage availability	+ or -	+	-	+ or -	0
Thermal cover	-	-	+	+ or -	+
Winter range	-	-	+	-	+
Hiding cover	- or +	-	+	- or +	- or +
Calving cover	-	-	+	+	- or +

a + Beneficial effect; - Detrimental effect; 0 No important effect.

they are much like clearing and subsequent planting in their effects; weeding and cleaning, because they are currently uncommon and often dependent on herbicides, which have a very uncertain future in B.C. forest management; and pruning, which again is uncommon and, in addition, should have few impacts on wildlife. The list of habitat values was similarly shortened. Several cover types were eliminated because their value to elk and deer is uncertain and unlikely to be significant in management. These included rutting, insect, resting, and playing cover. The effect of water availability is potentially important to elk but was not included because it is affected little by forestry except where human activity keeps animals away from water sources. Human disturbance is a topic best addressed by the deer and elk study teams with telemetry.

6.1.1 Forage abundance

During the earlier review of local literature on forage abundance it was pointed out that some old-growth forests produce more available forage, especially in winter, than do some clearcuts. This is not the usual case unless snow covers food in clearcuts, however; in the absence of snow, greater forage abundance in old-growth is most often observed when the forest and the clearcut being compared are on two radically different sites, or when the clearcut has been burned only one or two growing seasons earlier. When a forest is logged, ground vegetation usually increases dramatically within a few years, although slashburning or excessive soil disturbance during logging may delay the response. This phenomenon, combined with the greater visibility of deer in clearcuts, is largely responsible for the incorrect but long-held notion that blacktail deer in all areas of Vancouver Island and Alaska increase greatly with logging, and are uncommon in old-growth forests (Cowan 1945; Hebert 1979; Wallmo and Schoen 1980).

Many studies have shown an inverse relationship between the amount of overhead shade and the abundance of overstory vegetation (e.g. Anderson et al. 1969; Behrend and Patrick 1969; Long and Turner 1975; Regelin and

Wallmo 1978). A successional pattern dependent largely on light requirements of the understory has been postulated (Bunnell and Eastman 1976; Alaback 1978; Wallmo and Schoen 1981) for unmanaged coastal forests. In this scenario, clearcutting gives a large boost to understory production, which persists until crowns of the next tree crop begin to close. Understory production, and later biomass, then begins a long decline to very low levels under dense, young forest canopies and does not increase again until the stand reaches the over-mature stage and gaps begin to occur in the canopy due to senescence, windthrow, or insect and disease attack. Old-growth forests continue to support a substantial understory as long as the uneven canopy persists, but understory biomass is less than that seen after logging or fire.

The scenario just described is no doubt accurate for some sites, but, as shown earlier, certain Vancouver Island old-growth stands support crops of rooted forage as small as 40 kg/ha. If dense immature stands on the same site produced this amount or less, as is likely, deer and elk populations could be constrained to low levels by food shortages for long periods of time. For example, daily dry-matter forage intakes have been estimated at 22 g forage/kg body weight per day for deer (Wallmo et al. 1977) and 30 g/kg per day for elk (Mould and Robbins 1981). If we assume 40 kg as a mean deer weight for Vancouver Island and 200 kg as a mean elk weight, a forest with an average of 40 kg/ha of forage could support only about 12 deer/km^2 or 2 elk/km^2 year-round. Some younger Vancouver Island stands have far less than 40 kg/ha of forage - especially dense immature stands on mesic and wetter sites which probably produce as little as 7 kg forage per hectare. This amount of forage would support 2 deer/km^2, a level far below what would be considered a manageable population. In addition, young stands seldom support significant crops of forage lichens, and would therefore provide almost no food other than conifer litterfall during deep snow. Large tracts of dense immature forest could limit deer and elk populations to levels unsuitable for hunting or viewing.

Thinning has been proposed as a means of increasing forage production in young stands, and one local study has shown that salal, an important deer

food, is increased up to three times by heavy thinning and two times by light thinning on a mesic site in the drier Coastal Douglas-fir Zone (Stanek et al. 1979). Similar research in the southern and eastern U.S. has confirmed the potential of thinnings to promote forage growth (Halls and Schuster 1965; Grelan et al. 1972; Knierim et al. 1971). There have been fewer studies in the western part of the continent, and Bunnell and Eastman (1976) have suggested that pre-commercial thinning is unlikely to significantly enhance wildlife values in coastal B.C. because crown overstories will not be opened enough to promote understory. The results of Stanek et al. (1979) contradict this conclusion, especially since their "heavy thinning" left more residual stems than many forest companies do; but other plant communities in other subzones may react differently. The wide tree spacings used by some organizations (more than 4 m between trees in many cases) will likely produce more benefits than were anticipated by Bunnell and Eastman.

Fertilization of shrubs has been shown to promote growth in coastal Washington shrubfields (Nelson 1974) and in Alaskan cutovers (Merriam 1971). Near Campbell River, urea fertilization promoted growth of two forbs, a grass, and a trailing shrub (Rubus ursinus) in young stands with less than 50% tree cover, but in denser stands it increased growth only in bracken fern (Pteridium aquilinum) and Rubus ursinus (Ash et al. [1977]). At Shawnigan Lake, urea fertilizer decreased salal by nearly 50% under tree canopies in unthinned stands because it promoted greater crown growth, but in heavily thinned stands, fertilizer produced about 25% more salal than in similar unfertilized stands (Stanek et al. 1979). Bracken fern was not significantly affected by fertilization alone at any one thinning weight, and salal did not respond to fertilization under light thinning.

Because fertilization is applied to forest stands to increase tree growth, it can be expected that in most cases where crowns are dense at the time fertilizer is applied, understory response will be minimal or even negative. In more open stands some minor increase in abundance may be seen, but growth rates will probably return to normal levels after several years.

6.1.2 Forage quality

Changes in light intensity, soil nutrient availability, and competition for water and nutrients cause variable effects on understory forage quality. Einarsen (1946) found closed canopy forest to hold forage lower in protein content than did logged and burned areas elsewhere in Oregon. In California, 10 of 13 understory plants in open stands of giant sequoia (Sequoiadendron giganteum) had higher protein contents than they did under densely-canopied stands, but other quality measures such as fat, fibre, and nitrogen-free extract were much more variable (Lawrence and Biswell 1972). In Washington, Brown (1961) found no clear patterns in relative protein content of four species when comparing freshly logged, dense immature and old-growth stands in three different areas; but he concluded that inadequate sampling was the cause. In Alaska, protein contents were higher in blue huckleberry (Vaccinium ovalifolium) under mature canopies than in the open (Billings and Wheeler 1979). Cowan et al. (1950), working near Quesnel, B.C. found that protein contents in moose forage species could be highest in clearings or old forest depending on the species, but that young forests generally had intermediate or lower values than the other two forest ages. Ether and nitrogen-free extracts were similarly variable, but crude fibre was consistently higher in older stands than in clearings. On Vancouver Island, Gates (1968) found that forage quality did not decline in young stands between four and fourteen years of age. Rochelle (1980) found shrubs and ferns from Nimpkish Valley forests to be higher in crude protein than those from cutovers, but the differences were not statistically significant. Dry matter digestibilities were generally higher by a few percent (but not statistically significant) in shrubs, conifers, and ferns growing in cutovers.

These results indicate that intraspecific differences in forage quality resulting from forest succession are variable but usually minor. Some of the variability in results may be due to the sampling methods used, which often included compositing samples from unstandardized pieces of many individual plants. There is little indication that logging or thinning affect quality significantly.

Slashburning may produce short-term increases in protein content of forages (Einarsen 1946) due to mobilization of nitrogen from organic matter, but these increased levels are likely to persist only a few years. Fertilization will also boost protein contents (Ash and Bendell 1979), but nitrogen levels will again decline quickly (Merriam 1971).

6.1.3 Understory community composition

In addition to changes in the absolute quantity of forage, forestry activities can affect relative amounts of each species present in a stand. Such changes in understory composition commonly occur during the normal development of unmanaged stands; for instance, a grass-forb stage often dominates in clearings for 5 years or so following logging and burning. This stage is often followed by a shrub community; then after tree canopy closure, by reduced vascular plant proportions in favour of mosses, and by an eventual increase in herb and shrub proportions as the canopy opens and becomes uneven-aged. Long (1973) found that on some sites in coastal Washington, salal gained almost total domination of the understory by the time a stand was 22 years old, but decreased in dominance as the stand aged to 73 years.

There is some evidence that higher soil moisture levels in the B.C. portion of the Coastal Western Hemlock Zone, as compared to southern portions of the same zone, decrease the effects of disturbance on the initial stages of secondary succession. Mueller-Dombois (1959) concluded that severe or repeated burning was required in the Coastal Douglas-fir Zone to completely destroy the remnant vegetation from the pre-logging community, but that invading weeds often flourished for the first few years after logging and fire. Woody species present before logging were usually found in reduced numbers after fire. Near Haney, B.C., Kellman (1969) found that "primary" species (those present in old-growth stands) declined in abundance and vigour after logging and burning, but they persisted in the stand and gradually reassumed their former dominance. A "secondary" component of invading species was abundant in the earliest stages of post-logging

succession, but declined greatly by the time stands were 15 years old. The secondary species seemed to be responding to light availablility more than were the primary ones, indicating that they may be more able to increase after thinnings. Housknecht (1976) found similar persistence of species from mature forests in burned cutovers, and also noted that piling and burning reduced the number of persisting species less than broadcast slashburning.

Thinning effects on understory composition can not be extrapolated from other climatic regions, so the work of Stanek et al. (1979) provides the best indication of local effects. Unfortunately, their results are limited to only the two dominant understory species, bracken and salal. They found the ratio between salal and bracken biomass to change from 97:3 before thinning to 90:10 after. The abundance of both species increased greatly due to thinning.

Repeated fertilization, especially if combined with soil disturbance caused by machinery, may eventually eliminate from rich sites those species that are adapted to poor soils (e.g. ericaceous shrubs).

6.1.4 Forage availability

The availability of a forage resource to animals is a function both of its abundance and of the ability of animals to use it. Because abundance has been covered in a previous section, "availability" is used in this section to refer to the physical restrictions that prevent or encourage the use of the existing biomass of forage.

The physical restrictions on use could be a function of plant form (height, number, and size of shoots and leaves) or access (debris accumulations or snow). Logging may affect forage availability positively, by stimulating growth of small plants; or negatively, by creating debris that impedes access. Burning generally increases availability (not abundance) by reducing debris accumulations. Establishment of young forests through planting or natural regeneration will decrease availability, and fertilization should have little effect either way. Thinnings will increase

availability by encouraging establishment of small plants, but access could be greatly reduced if debris is heavy.

6.1.5 Thermal cover

Good thermal cover is provided by dense overhead canopies which reduce radiative and convective heat losses, and thick ground level vegetation which also reduces wind (Thomas et al. 1979). The overhead canopy is regarded as most important. Thomas et al. set 70% canopy closure in coniferous stands 12 m or taller as a minimum standard for elk thermal cover, and specified an optimum size range for such stands as 12 to 24 ha. For deer, which unlike elk are usually solitary or in small groups, summer and spring-fall thermal cover is supplied by evergreen and deciduous saplings or shrubs at least 1.5 m tall, and with 75% or more canopy closure. For winter thermal cover, all vegetation must be evergreen and pole-sapling size or larger. A minimum width of 91.5 m is recommended for deer thermal cover patches, with an optimum size estimated to be 0.8-2 ha.

These thermal cover recommendations are based on the assumption that deer and elk need thermal cover, i.e. it is an essential component of their habitat. As discussed earlier, that assumption may not be valid for Vancouver Island under any but the most extreme weather conditions. Wallmo and Schoen (1981, p. 436) have concluded that "mule deer's ability to tolerate, with apparent comfort, climates as extreme as Alberta winters and Chihuahua summers suggest a thermoregulatory capacity great enough to make the minor microclimate modification provided by forest cover rather insignificant." Even if thermal cover is required, it may not be necessary under all conditions to have patches larger than 0.8 ha as prescribed by Thomas et al. (1979). When shade is needed, single trees or large shrubs can provide shelter for one or two animals. Even in cold weather, single trees may be valuable. Moen (1968) presents data indicating that a single conifer can emit the same amount of radiation per unit area at its base as a continuous stand.

If thermal cover is needed, forestry activities such as logging and burning that remove trees and shrubs or reduce canopy closure will reduce

habitat value. Those practices promoting vegetation growth, such as planting and fertilizing, will have a beneficial effect. Thinning will have both positive and negative aspects because it reduces canopy closure initially but stimulates understory growth.

6.1.6 Winter range

Snow packs are usually shallower under tree canopies than they are in the open. Harestad and Bunnell (1981) present regression equations showing that snow interception increases with increasing canopy closure.

Logging and burning reduces winter range value by removing trees and other vegetation. Planting, natural seeding, and fertilizing increase winter range value by increasing overstory biomass, but the beneficial effects of small trees may be minimal. Thinning will reduce winter range value initially, but may have long-term benefits if the larger crowns produced from thinning are more effective at intercepting snow.

6.1.7 Hiding cover

Because hiding cover is dependent on vegetation density near ground level, any practice promoting the growth of tall evergreen shrubs or small conifers should have beneficial effects. Tall deciduous shrubs and small deciduous trees will benefit hiding cover only in summer, unless stems are very dense. Tree boles in extremely dense stands may provide hiding cover even if the understory is sparse.

Logging will usually decrease hiding cover initially due to tree removal and understory destruction, but re-establishment of tall shrubs will provide improved cover on some sites, compared to pre-logging conditions. Planting and natural seeding will improve hiding cover; burning will reduce it. Thinning will improve hiding cover if tall shrubs increase greatly, but on many sites an increase of low shrubs and herbs will be of little benefit. Fertilization may be either beneficial or detrimental, depending on whether it stimulates understory growth or indirectly decreases it by promoting crown development.

6.1.8 Calving cover

Elk calving cover will be reduced by logging and burning due to tree and shrub removal. Planting, natural seeding, and thinning should be positive in their effects, and fertilization may again be good or bad, for the same reasons as for hiding cover.

7 PRIORITIES

7.1 Study Areas

Our studies should concentrate on areas where high deer and elk capabilities and management priorities overlap with high forest capabilities and widespread intensive silviculture. Figure 1 shows the Fish and Wildlife Branch's current perception of Vancouver Island deer capability. No similar map is available for elk. In general, forestry capabilities are highest in the drier and wetter Coastal Western Hemlock subzones for Douglas-fir and western hemlock respectively, with lesser but still relatively high capabilities for Douglas-fir in the wetter Coastal Douglas-fir subzone.

It is difficult to map biogeoclimatic subzones at small scales because of their complex interspersal in mountainous terrain, so no map of subzones is presented. Subzone distribution can be described in general terms. The Coastal Douglas-fir Zone is restricted to the east coastal plain from Victoria north to Campbell River (Klinka et al. 1979). Most of the inland portion of this area is in the wetter subzone. The Coastal Western Hemlock Zone covers most of the rest of the island, except for high elevation areas lying in the Mountain Hemlock and Alpine Tundra Zones. In the mountainous central region, the drier CWH subzone lies below about 700 m elevation. The wetter subzone is found between the upper edge of the drier CWH subzone and the lower edge of the Mountain Hemlock Zone, except on the west and northern coasts of the island, where it extends to sea level and is the predominant biogeoclimatic unit.

The forest capabilities of these biogeoclimatic units suggest that future intensive forest management activities will be greatest in the

mountainous centre of Vancouver Island (on easily accessible sites), on the north coast, and on the west coast. The east coastal plain will also see significant intensive management programs on the larger blocks of forest land.

The areas rated as having high deer capability (Figure 1) within the CWH subzones are: (1) in the eastern portions of the central mountain spine; (2) the east half of the island from Campbell River to Port McNeill; (3) the area around Quatsino Sound from Port McNeill and Port Hardy west to the mouth of the Sound; and (4) the Nootka Island to Kyoquot area of the west coast, including small islands and the coastal fringe of Vancouver Island. Large elk herds are found in some of these areas, but other locations outside the high capability deer areas also seem to have high elk capabilities, such as the Tahsish River and Power River drainages.

As much as possible, habitat studies should be restricted to areas of high deer and elk capability. There will be cases, though, where suitable study sites for investigating the effects of certain forestry practices will not be available in those areas. The habitat sampling program may be extended to other portions of the island to fill these data gaps.

7.2 Study Topics

Two types of criteria must be used in choosing IWIFR research topics. First, the desirability of investigating any problem must be judged by its magnitude, as determined by such factors as its geographical extent, our current level of knowledge about it, and the potential management changes that could result from a better understanding of the problem relationship (see Ellis 1980[8] for a more complete analysis of decision criteria).

Second, logistic and economic constraints to our program cannot be ignored, because these set limits on the amount that can be accomplished. Division of the IWIFR budget amongst three major studies (habitat, elk, and

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[8] Ellis. op. cit.

deer) and a number of support studies has led to tight restrictions on the amount of equipment and labour that can be expended on any one program.

For these reasons the following assumptions were used as guides to the research priorities explained in this section:

1) the habitat value being affected by intensive forestry must be one that has a large effect in determining the carrying capacity of a given elk or deer range unit;

2) the forestry/habitat interaction must be widespread in geographic extent on Vancouver Island (e.g. effects of broadcast herbicide application on spring range are not a priority because the practice is so uncommon);

3) the likelihood of gaining valuable new knowledge about the habitat/forestry interaction must be high;

4) total expenditures for habitat research from IWIFR, during 1982-83 and subsequent years, must be limited to about $60,000 annually. This will support two full-time staff and provide ample travel and equipment budgets, but will not allow for more staff or expensive analysis of samples or data;

5) where possible, IWIFR habitat work should be coordinated with other studies funded separately (e.g. universities, forest companies) to take advantage of extra analytical or data-gathering opportunites;

6) habitat research should be phased, the highest priority topics to be addressed first and other topics addressed afterwards if time, budgets or priority changes dictate; and

7) plant phenology and other seasonal variations (e.g. snow) will prevent some studies from being carried on all year long, and thus activity may shift from one topic to another during the year.

7.2.1 Priority one: Winter range

Winter range for deer remains the focus of most forestry conflicts on Vancouver Island. Elk winter range has not been of as great concern, but it may be equally as important in areas with high snowfall. As explained

earlier, the best winter ranges are certain old-growth stands that are rapidly disappearing, and pressure is mounting to allow logging of the remaining reserved stands.

It may be possible to duplicate some or all of the key winter range characteristics in younger stands, but this will almost certainly mean adopting special forms of stand management not commonly practised on the coast, leading to higher logging costs, potentially lower timber yields, and somewhat lengthened rotations. Higher costs would likely be acceptable if they were compensated by revenue generated from logging of old-growth ranges. The objective of these different silvicultural systems would be to provide similar redistribution or reduction of snow packs as seen in old-growth winter ranges, and to furnish forage to which animals would have access during all but the worst snow conditions.

It is not possible to achieve old-growth tree sizes in short rotations (less than 100 years) and it may be equally difficult to grow arboreal lichens in dense, young stands. However, by using systems such as group selection (Daniel et al. 1979), or by using even-aged management approaches on small areas to produce forage within vigorous stands with dense canopies, we may be able to create a mosaic of age classes and tree sizes on winter ranges that would serve the same purpose as old-growth.

Little is known about the processes creating special snow and forage conditions in old-growth stands as compared to stands nearing rotation age; we do not even know whether both snow conditions and forage are always better in old stands. Do the larger trees hold up snow until it falls in a clump, packing down beneath them; or do the patchy canopies in old-growth stands cause winds to redistribute snow from dense to more open portions of the winter range? Which is more important to deer and elk in coastal B.C.: minimizing energy outputs by finding the shallowest, densest snow possible; or increasing energy intake by travelling through deeper snow to get more food? Are lichens a critical winter range feature? If so, how can they be produced in younger stands?

Answers to these and other relevant questions about winter range will not come quickly. Comparisons must be made between old-growth stands

(baseline conditions) and younger stands; and functional relationships between trees, snow, food, and animals must be defined. However, in light of the importance of this issue to managers of both forests and wildlife, it must rank as our first research priority. In addition, much of the groundwork for investigating tree-snow and deer-snow relationships has been laid by F.L. Bunnell and others at the University of British Columbia, giving us a good opportunity to co-ordinate our activities with them. Our role could be in gathering additional field data to supplement the U.B.C. work on trees and snow or deer and snow, but there is also a need for more investigation of forage production, availability, and use in winter ranges, both for rooted and arboreal forage.

Details of the specific winter range research topics and study plans require discussion by the IWIFR Technical Working Group and U.B.C. investigators, and will be explained in the working plan.

7.2.2 Priority two: Forage abundance

Without intensive forest management, deer and elk forage supplies would be minimal under dense stands of young conifers, due to the deep shade thrown by the trees. On many unproductive and inaccessible sites this situation will be common, but in intensively managed stands, thinning offers the opportunity to produce forage through most of the rotation period. The amount and type of food produced will depend on site features, the understory plant community, and the forest management regime; but selection of the appropriate regime and site will give the wildlife habitat manager a useful new tool.

Understory abundance must be integrated with plant community composition in assessing forage responses to thinning. If a single species such as salal gains dominance to the exclusion of all others, the light-biomass response may be much different than if other plants with different shade tolerances were present. Ideally, both the intra-specific and inter-specific responses of plants to various thinning weights should be analyzed, but that will not be feasible. Instead, existing stands will have to be

classified by site and climatic characteristics, past management history (e.g. age, previous thinnings, site preparation employed when establishing the stand). Questions to be answered will include: To what degree must a closed canopy be opened, in various biogeoclimatic subzones and on different sites within those subzones, to produce a significant increase in forage production for either deer or elk? How many thinnings must occur during the rotation period to maintain this level of forage production? Does BCFP's "piece-size" management regime offer advantages over MB's "volume" regime? Would wider spacings than those now commonly seen produce more forage on any or all sites?

To study the effect of thinning on understory, a large set of plots is available as potential study sites. These plots were originally established to monitor tree responses, and consist of Forest Productivity Committee plots from the early 1970s; Forest Service Research plots dating to the 1920s; and federal, university, and company installations. There are unthinned control plots at most experimental sites, and many sites have several replicates of each treatment, so it should be possible to make valid a posteriori conclusions about understory responses.

With this approach it will not be possible to sample vegetation changes on individual plots after treatments, but funding levels will not allow for extensive experimental thinnings.

7.2.3 Priority three: Hiding cover

We know that vegetation has an important effect in concealing animals, and that the proximity of cover influences the amount of use received by open areas such as clearcuts. We do not, however, have standards to define what adequate hiding cover is, and thus cannot prescribe what will or will not suffice. If hiding cover is adequately defined as being vegetation or topographic features that provide concealment at a given distance, it should be easy to measure and correlate to vegetation parameters. This is especially true in planted clearcuts and thinned stands where uniform spacings, tree sizes, and tree shapes should make winter hiding cover values

predictable based on tree height and density. Abundant deciduous understories during summer and evergreen ones all year will make the issue more complicated. Still, a simple sampling strategy using a sighting target should give us some useful data in a few man-weeks of field time.

Sampling of hiding cover can be extended to specific areas used by transmitter-equipped deer and elk, providing a link with the levels of cover that animals choose under given circumstances.

7.2.4 Priority four: Thermal cover

As discussed above, the need for thermal cover in the mild Vancouver Island climate is questionable, although it may be that summer temperatures on the hottest days create thermal stress sufficient to make shade a necessity. It is unlikely that shade could ever become limiting on Vancouver Island forest land, so we need not invest much time and money in studying thermal cover. However, weather stations equipped with automatic microloggers will be available. These will be suitable for making comparisons of microclimate among habitat types, and will also be employed for baseline weather readings in deer and elk study areas, as well as winter range weather monitoring. They may also be employed to provide initial indications of the ability of managed stands to reduce convection and radiation extremes.

7.2.5 Priority five: Debris

The heavy debris accumulations that occur in backlog thinned stands may cause mobility problems for deer and elk for years to come, but similar slash piles will not be seen as thinning occurs in younger stands with much smaller trees. However, even lesser debris loads may discourage use of some thinned stands, especially by elk. If observations by deer or elk study teams indicate that debris is shifting use away from some sites, sampling can be conducted to establish comparative debris loads between habitats such as clearcuts (burned and unburned) and thinned stands.

7.2.6 Other topics

Investigation of the effects of intensive management on forage quality is not proposed because there appears to be no evidence that forestry activities will cause changes in digestible energy, protein, or mineral content that could compare in magnitude with changes in biomass or community composition. Also, the task of sampling a representative deer or elk diet from even two treatment units would be difficult and expensive, considering the need to account for such factors as differential nutrient concentrations within plants, the diverse and seasonally varying nature of the diet in both species, and the time-consuming analyses required to produce an estimate of mean and variance for each quality variable in each diet.

Calving cover for elk is not addressed as a specific study topic, although its suspected importance was discussed previously. The three component characteristics of this cover type seem to be abundant deciduous forage, good visual screening near the ground, and the proximity of open water. The first two features will be covered in the forage abundance and hiding cover studies proposed, and the third is little influenced by forestry. Elk telemetry studies should point out locations where this cover type occurs, and where further details of its nature could be studied.

7.3 Habitat Descriptions for the Deer and Elk Studies

Much of what has been proposed above can be conducted in isolation from studies using deer and elk as subjects. This will in fact be necessary because the range of climates, soils, and forestry treatments available for sampling would be too limited if habitat studies were restricted to the three or four localities where telemetry is to be conducted. However, there will be a need to maintain communication and coordination between the habitat, elk, and deer studies, both to ensure that the habitat preferences and needs shown by the animals are understood by those evaluating potential habitat elsewhere, and to make the special expertise resident in each study team available to the others.

In addition, there will be a need for habitat description and evaluation to be conducted in deer and elk ranges, particularly those where intensive telemetry will be used to monitor microhabitat selection. There will be much to gain in having the habitat team work with the deer and elk crews in describing and evaluating these habitats, because the knowledge and experience of forestry and forest ecosystems which should be possessed by the habitat crew will be needed in that work. In some cases, time permitting, it will probably be the sole duty of the habitat team to describe and classify habitat units.

It is proposed that the habitat crew should spend about 20% of its field time working directly with the deer and elk crews in their study areas. There should be opportunities for co-operation in all aspects of habitat studies, especially snow-habitat-animal investigations, hiding cover, and thermal cover. Where possible, habitat studies in deer and elk areas should be conducted in blocks of time such as two weeks at a stretch, to allow longer and less frequent sampling trips to other parts of Vancouver Island. This will mean that day-to-day habitat characterization in areas used infrequently by transmitter-equipped animals will have to be performed routinely by the deer and elk study teams. Such sampling will be less intensive than much of what the habitat crew will do, but can easily include measures of hiding cover and general stand characteristics plus estimates of understory composition and cover. More detailed work, where required, can be conducted at a later date if the location is marked for future reference.

8 SUMMARY

This problem analysis evaluates research priorities for studies of the ways in which intensive forest management will affect habitat values for deer and elk on Vancouver Island. Field studies will follow to investigate certain aspects of the forestry/habitat problem. Other studies are being conducted to investigate relationships between elk and deer populations and their habitats.

On Vancouver Island, depletion of old-growth timber inventories has led to an increased emphasis on managing young-growth forests in which deer and elk habitats are poorly understood. Intensive management programs will be extensive in areas of high Douglas-fir and western hemlock capability, including the wetter subzone of the Coastal Douglas-fir Biogeoclimatic Zone, and both the drier and wetter subzones of the Coastal Western Hemlock Biogeoclimatic Zone. Elk and deer capabilities are high in many portions of these subzones, including most of the east half of Vancouver Island and around Nootka, Kyoquot, and Quatsino Sounds on the west coast.

Among all the habitat values provided by Vancouver Island forests, the most important ones are high-quality forage, winter range (which includes a forage component), thermal cover, and hiding cover. These values will be most affected by logging, burning, planting, thinning, and fertilization in the next few years. Both positive and negative effects on habitat will result from these practices.

Habitat/forestry research should concentrate on areas of high elk and deer capability in the Coastal Western Hemlock Zone, with lower priority given to the wetter subzone of the Coastal Douglas-fir Zone. The two research questions of highest priority are: 1) how can forestry treatments be used to promote deer and elk winter range values in young stands; and 2) how do thinning and fertilization affect forage abundance and species composition in immature stands? These questions will be addressed in the initial stages of the program, with research on hiding cover, thermal cover, and forage quality to be considered for research later in the program.

The work of the habitat study team will be integrated with that carried out by the deer and elk study teams, so that at least 20% of their working time is spent together.

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10 APPENDIX

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10.1 Glossary

backlog - sites or stands that are past the optimum age for a particular treatment

basic silviculture - a term used by the B.C. Forest Service to classify the simplest level of forest management; includes planting, site preparation, brushing, and weeding

brushing - cleaning

cleaning - a loose term for a cultural operation eliminating or suppressing undesirable vegetation (mainly woody) during the thicket stage of a forest crop, thus before, or - at the latest - along with, the first thinning, so as to favour the better trees; may include unwanted crop species as well as intrusive vegetation

climax - the culminating stage in plant succession for a given environment, in which the vegetation is considered as having reached a highly stable condition

commercial thinning - any type of thinning producing merchantable material at least to the value of the direct costs of harvesting

dbh - diameter at breast height (1.3 m)

fall-down effect - the fall in allowable cuts as high-volume old-growth stands are logged and replaced by new crops

hack and squirt - a herbicide application technique in which the poison is introduced from a squeeze bottle or other spray device into an incision in the bark and cambium

immature - any stage before a tree, crop, or stand is mature

intensive forest management - the practice of forestry so as to obtain a high level of volume and quality of wood products per unit area, through the application of the best techniques of silviculture and management

intensive silviculture - a term used by the B.C. Forest Service to classify the most intensive level of forest management; includes backlog planting, pre-commercial and commercial thinning, fertilizing, type converting, and conifer releasing

juvenile spacing - pre-commercial thinning

mature - the stage at which a tree, crop, or stand best fulfils the main purpose for which it was maintained, e.g. produces the best possible supply of specified products or earns a specified rate of interest. It is usually equated to a rotation age of from 50 to 100 years

mean annual increment - the total increase in girth, diameter, basal area, height, volume, quality, or value of individual trees or crops up to a given age, divided by that age

old-growth - natural forest virtually uninfluenced by human activity, and beyond the mature stage - typified by very large trees, an uneven age structure, and high structural diversity both horizontally and vertically

piece-size management regime - a regime designed to achieve a product objective described by log size or quality. Age at harvest is determined by the technical rotation

pre-commercial thinning - any type of thinning not producing merchantable material at least to the value of the direct costs of harvesting, usually practised in stands under 20 years of age

pruning - the considered removal, close to or flush with the stem, of live or dead side branches and of multiple leaders from a standing, generally plantation-grown tree, for the improvement of the tree or its timber

regime - a series of forestry treatments applied to a crop or stand in order to achieve the product objectives

release - freeing a tree or group of trees from more immediate competition by cutting or otherwise eliminating growth that is overtopping or closely surrounding it

rotation - the planned number of years between the formation or regeneration of a crop or stand and its final cutting at a specified stage of maturity

scarifying - loosening the top soil of open areas or breaking up the forest floor in preparation for regenerating by direct seeding, natural seedfall, or planting

second-growth - forest growth that has come up naturally after some drastic interference (e.g. wholesale cutting, serious fire, or insect attack) with the previous forest crop

selection cutting - the annual or periodic removal of trees (particularly the mature) individually or in small groups (i.e. group selection) from an uneven-aged forest in order to realize the yield and establish a new crop of irregular constitution

silviculture - generally, the science and art of cultivating forest crops; more particularly, the theory and practice of controlling the establishment, composition, constitution, and growth of forests

site preparation - a general term for removing unwanted vegetation, slash, and even stumps, roots, and stones, from a site, as before reforestation

site rehabilitation - type conversion

technical rotation - the rotation that yields the greatest volume of material suitable for a specific purpose or purposes

tending - generally, any operation carried out for the benefit of a forest crop or an individual thereof, at any stage of its life; covers operations both on the crop itself (e.g. thinnings), and on competing vegetation (e.g. weeding and cleaning, but not site preparation)

thinning - a felling made in an immature crop or stand in order primarily to accelerate diameter increment but also, by suitable selection, to improve the average form of the trees that remain

thinning intensity - a measure of the combined effect of thinning weight and thinning frequency, in terms of the volume removed during any succession of thinnings

thinning frequency - the lapse of time between successive thinnings in the same area, whether the thinning interval is regular or irregular

thinning weight - a degree of thinning expressed in terms of the volume removed at any one time (hence "light", "moderate", "heavy")

type conversion - a change from one (set of) tree species to another, usually from broadleaved to conifer

volume management regime - a regime designed to maximize merchantable volume over the rotation period-age at harvest as determined by the culmination of mean annual volume increment (rotation of maximum volume production)

weeding - generally, a cultural operation eliminating or suppressing undesirable vegetation, mainly herbaceous, during the seedling stage of a forest crop and therefore before the first cleaning, so as to reduce competition with the seedling stand

young-growth - forest stands or crops that have not yet reached the old-growth stage

10.2 Personnel Contacted

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